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ABSTRACT

The 46 papers is this volume represent some of the most current thinking in educational communications and technology. Individual papers address the following topics: gender differences in the selection of elective computer science courses and in the selection of non-traditional careers; instruction for individuals with different cognitive styles; the teacher's role in integrating instructional technology; affective-cognitive learning; factors influencing mental effort; educational technology and integration; computer screen layout design; graphic format, cognitive style, and recall of quantitative data; semiotic theory and educational technology; international students and the use of educational media in their home countries; teachers and technology; elementary teachers, psychological types, and uses of educational computing; computer-based instruction, problem-solving skills, and middle-level students; secondary computer-based instruction in macroeconomics; distance education; learner control and interactive video; rules and higher order rules; satellite communications and high school education; best colors for audiovisual materials instruction; structure and organization in instructional text; instructional plans and situated learning; microcomputer-based instruction program strategies and verbal and visual testing; intelligent computer-assisted instruction; Fishbein Model and normative influences on behavior; and skipping of subordinate skills. Also included are a symposium on interactive video and Richard Clark's media research. Cumulative author and descriptor indexes for the 1989 conference proceedings are provided. (CGD)

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PROCEEDINGS OF SELECTED RESEARCH PAPER PRESENTATIONS

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in
Dallas, Texas

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PREFACE

For the eleventh year, the Research and Theory Division of the Association for Educational Communications and Technology (AECT) is publishing these Proceedings. Papers published in this volume were presented at the national AECT Convention in Dallas, Texas. A limited quantity of this volume were printed and sold. It is also available on microfiche through the Educational Resources Information Clearinghouse (ERIC) system.

REFEREEING PROCESS: All research papers selected for presentation at the AECT Convention and included in this Proceedings were subjected to a rigorous blind reviewing process. Proposals were submitted to either David Jonassen of the University of Colorado at Denver or Dr. Dean Christensen of the Control Data Corporation in Minneapolis, Minnesota who coordinated the review process. All references to author were removed from proposals before they were submitted to referees for review. Approximately fifty percent of the manuscripts submitted for consideration were selected for presentation at the Convention and for Publication in these Proceedings. The papers contained in this document represent some of the most current thinking in educational communications and technology.

This volume contains two indexes covering this volume. The first is an author index; the second is a descriptor index. The two indexes will be updated in future editions of this Proceedings. The index for volumes 1-6 (1979-84) are included in the 1986 Proceedings, and the index for volumes 7-10 is in the 1988 Proceedings.

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Title:

Gender Differences in the Selection of Elective Computer Science Courses

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01

Gender Differences in the Selection of Elective Computer Science Courses

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A paper presented at the national conference of the Association for
Educational Communications and Technology
Dallas, Texas
February, 1989

INTRODUCTION

Computer use in our society is growing at an extremely rapid pace. Many aspects of our daily lives such as shopping, banking and workplace activities have changed dramatically because of the effects of computers. The U.S. Department of Labor estimates that 50-75% of jobs will involve computers in some way by the time today's high school students enter the job market (Sanders, 1984). In this decade and increasingly in decades to come, computer related fields will be offering many of our society's best professional employment opportunities (Sanders, 1984). During the last five years, educators throughout the United States have recognized this trend and have responded by increasing the incorporation of computer study in schools.

As computers become increasingly accepted in schools, many people are concerned that gender equity is being ignored. According to Anderson et al.(1984) and Lockheed et al.(1984), computer learning opportunities are less common among females. This problem seems to stem from the already well-defined pattern of inequality, which exists throughout our school curricula and society in general. Indeed, computer study may be exacerbating this situation by reinforcing existing gender inequities rather than encouraging educational equity (Schubert, 1986).

This problem of inequity in computer studies (i.e. unequal access to computer resources by females) has several serious implications for the future. Anderson et al. (1984) write:

> Educational computer inequity threatens to separate groups and communities by giving some people more effective tools for living in the age of computer information systems (p.10).

Sanders (1984) supports this view by arguing that gender related differences among students today in computer education are likely to result in occupational and economic sex discrepancy in the future.

In many elementary and middle schools, students' participation in computer classes is compulsory, and thus, every student in those schools should have equal opportunities to learn about computers. However, a number of recent studies have indicated that most of the students working with computers at the high school level are male, and as age increases, female enrollment in computer classes decreases. For instance, in a study of Princeton High School students, it was found that 60% of male students, and only 8% of female students used school computers voluntarily before, during, and/or after classes (Sanders, 1984). Also, in a study of freshman students from an introductory psychology class at a midwestern state university, Dambrot et al. (1985) found that female students showed more negative attitudes toward computers and scored lower in computer aptitude tests than male students. Furthermore, McCain(1983) found that female students show a tendency to take general introductory computer courses rather than more advanced courses.

Other studies have found sex not to be significantly related to students' computing abilities and their attitudes toward computers. For example, Loyd and Gressard (1984) surveyed 354 high school and college students concerning their attitudes toward computers. They found no evidence to indicate any difference between males and females in terms of computer anxiety, computer confidence, and computer liking. Further, Mandinach and Fisher (1985) found that females and males performed similarly once they enrolled in computer programming courses.

The results are inconclusive concerning gender equity in computer classes in high schools. Some school districts may differ from others in regard to this problem. The ratio of males in computer classes may differ according to the level of the class. Finally, where gender related differences in high school courses can be found, the factors which contribute to the problem are yet fully understood.

Educators need to realize serious impacts of gender inequity on students' future and try to achieve gender equity in computer education. Thus, the first step in this process is to identify possible factors influencing the differences. As Schubert (1986) contends, gender related differences in computer education are influenced more by external factors than by internal ones, and hindrances to equitable encouragement of female and male students' computer learning are due to various sources. It is possible that in some cases, gender related differences may be influenced by social expectations, familial influences, peer pressure, career plans, and school policies which assign differential attitudes towards computer study to male and female high school students.

PURPOSE

The purpose of the present studies was to investigate the existence of gender related differences in high school elective computer courses in a midwestern urban area and factors affecting the differences. A 1987 study and a 1988 follow-up study have been conducted to the students enrolled in high schools in the Madison Metropolitan School District in the state of Wisconsin. The first study focused on three key areas of concern. First, it examined to what extent if any, there existed gender related differences in actual enrollment figures. Second, it also seeks to determine whether gender related differences were in any way related to computer course levels. Third, it explored possible factors influencing the differences. Previous research indicates that there may exist a relationship between students' attitudes toward computers and their participation in computer classes. Further, these attitudes may be related to other factors such as role models and future career plans. The study intended to identify high school students' attitude toward computers and to determine whether they differ in relation to student gender, computer course level, role models, experience with computers, and students' future plans concerning computer careers.

A study follow-up conducted to extend the findings of the first study. In the second study, the students who were not enrolled in elective computer courses as well as those who were enrolled in the courses were surveyed. The purpose of the study was to examine differences between students who have taken at least one elective computer course and those who have not taken any in relation to their gender, attitude toward computers, experience with computers, plans for taking more high school computer classes, future plans concerning computer careers, and role models. In addition, the researchers explored how students who have taken at least one elective computer course felt about the overall course, and peers and teachers in the course.

STUDY 1

Objectives

The following research questions were examined:

1) Is there a gender related difference in enrollment in computer courses?

2) Does the difference in enrollment change as the level of computer class increases?

3) Do gender and course level related differences exist among students enrolled in computer classes in terms of the following criteria:

general attitudes toward computers
confidence with computers
perceived usefulness of computers
gender related bias toward computer use
plans for further computer study or professional work
role models
experience with computers

Method

A survey was administered to the total population of students enrolled in high school elective computer courses in the Madison Metropolitan School District during the fall of 1987. There were a total number of 166 respondents, 104 of which were male and 62 of which were females. Data were also collected from four high schools in the district concerning male and female enrollment numbers for all beginning and intermediate computer classes.

A survey was developed which addressed attitudes towards computer use. The first part of the survey was adapted from a computer attitude scale used in a published study (Swadener and Hannafin, 1987). It consisted of seventeen questions utilizing a five item Likert scale ranging from strongly disagree to strongly agree and posed questions concerning general attitudes toward computers, self confidence, computer utility, and sex bias.

The second part of the survey consisted of questions relating to male and female role models who use computers, total time spent with computers, and plans for future computer study and professional work.

The data on enrollment figures were analyzed using the Chi-square test of population to determine any differences between males and females and introductory and intermediate level courses.

The data concerning the other variables addressed by the survey were analyzed according to gender and course level differences by comparing their means and performing an analysis of variance (one way ANOVA).

Results

The differences between males and females in beginning and intermediate class were most apparent in the role models available to the students, sex bias and their view of gender differences. The general attitude of the students, perceived usefulness and self confidence in use of computers did not produce significant differences. The charts and graphs illustrating the differences that were found are presented in the appendix 1.

The difference in the numbers of computer students is illustrated by chart 1. The number of females is less for beginning computer courses with the largest difference appearing in the intermediate courses. Anecdotal information from computer teachers indicates that these differences are historical and that the number of beginning class females is usually lower.

The role model data presented (charts 2-5) show that female students in computer classes tend to have a larger number of role models than the males in these classes. This apparent difference is larger for females with female role models than females with male role models.

The attitudes of computer students about males and females in relation to computers is given in sex bias and perceived differences charts 5 and 6. The stereotypical sex bias of males and computers is higher for males than for females with a slight increase from first to second courses. The perception of computers as a male domain is high for beginning females and nonexistent for intermediate females while the same perception increased for males (some student wrote the the low participation of females in intermediate courses is proof of a difference).

Discussion

Some of the more popular beliefs about differences between males and females seem not to be present in this study. The attitudes of females appear to be just as positive toward computers as that of the males in the study. The difference in the sex bias and perceived differences between male and female abilities appear to be related to a readily observable drop in female enrollment in intermediate computer science classes. The striking difference in the total number of role models and female role models for female students in intermediate computer science courses could have the greatest practical significance. The positive encouragement of parents and friends may make the difference between contribution in computer study for females.

Further Study

The differences between females in computer classes and those not taking computer classes would be an avenue of pursuit. The factors that contribute to low enrollment of females in computer science may be evident in students that do not take such courses. There may also some differences between females enrolled in computer science courses and business education computer courses.

STUDY 2

Objectives

The research questions that guided this follow-up study were:

1) Do gender related differences exist between students who have taken at least one elective computer course and those who have not taken any computer course in terms of the following criteria:

general attitudes toward computers
confidence with computers
perceived usefulness of computers
gender related bias toward computer use
plans for further computer study or professional work
role models
experience with computers

2) Do gender related differences exist among the students who have taken at least one elective computer course in terms of the following criteria:

feeling toward the course
interaction with peers in the course
interaction with teachers in the course

Method

This study was conducted in the fall of 1988. Students who were not enrolled in computer courses as well as the students enrolled in computer courses were surveyed. There were a total number of 328 respondents, 195 of which were male and 133 of which were females. Data were collected from the three high schools in the Madison Metropolitan School District. All the students enrolled in computer courses in the three schools were surveyed. Non-computer science student results were obtained by randomly selecting homerooms and having students in the selected homerooms answer the survey. Those who were enrolled both in computer courses and in the selected homerooms did not complete the survey a second time.

The survey developed for the first study was added to and modified for the second study (appendix 4). In part two of the original survey, the following questions were added: whether students have taken any high school elective computer courses or not; how many elective computer courses they have taken in high schools; if they have taken any, how they felt about the overall course, and peers and teachers in the course; and whether they plan to take a computer course later in high schools. A role model check list matrix was developed to replace open-ended questions concerning use of computers by acquaintances in the workplace, home and school. Space was provided for comments about gender related attitudes, computer learning and the importance about computers on the page three as well as for additional overall comments on the page four.

The data concerning students' future plans and attitudes were analyzed using the Mann-Whitney U test to determine any difference between the students who have taken at least one elective high school computer course and those who have not taken any elective computer course in high school. The same test was also used to determine any difference between the students who intend to take a computer course in high school and those who do not intend to take it in relation to their future plans, attitudes and (if they have taken any computer course) their overall feeling toward the course and interaction with peers and teachers in the course.

The data on total time spent with computers and role models were analyzed by performing the T-test to explore any existence of difference between the students who have taken any elective computer course and those who have not, and between those who intend to take a computer course in high school and those who do not intend to take a course.

Further, in order to establish the strength of the relationships, Pearson R Correlation was calculated for interval data and the Spearman R correlation for Likert scale data. All the statistical analyses were conducted for males and females separately.

Results

Differences between the students who have taken a computer course (tables 3 & 5) and those who have not and between those who intend to take a high school computer course and those who do not were significant for both males and females (appendix 2 contains tables 1-8). Plans for taking a computer course after high school, plans for having a computer related job, perceived usefulness of computers, general attitudes toward computers and confidence with computers were all more positive for computer course students and those who intend to take a computer course. For students' gender related bias toward computer use, differences were apparent only for males. Significant differences were found for both females and males who intend to take a computer course and plan to major in computer science in college. No difference was found for those who have and have not taken computer courses.

Students who have taken a high school computer course (table 7) were asked to describe their overall feeling toward the course, the difference between those who intend to take a computer course in high school and those who do not was significant only for females. Students' overall feeling toward interaction with peers and teachers showed no significant difference.

The correlation data with regard to plans for computer work after high school (table 4) show slight to moderate relationships with computer course participation and the desire to take a computer course. These correlations, however, show little difference between males and females. It can be noted that the only comparisons that were not slightly correlated were for both males and females who have taken a computer course.

The attitudes of respondents (table 6) show mostly moderate correlations in relation to course participation and expressed intent for a computer course. There is little difference in correlations for males and females on any of these scales. The negative values for the sex bias scale is the result of inversion of this scale (less bias is a lower value on the scale).

For students who have taken computer class, the correlation between expressed interest in another course (table 7) and whether they liked the current/past computer course was moderate. The correlation for males and females was similar. All other cells show slight or no correlation.

The hours of use for male and female computer students (table 8) was substantially different than for those who have not taken a computer course. The correlation value for these factors was moderate. The difference between intent to take a course in relation to hours of computer use was only significant for males. The correlation for both males and female was slight.

Role models for students both intending to take a computer course (tables 1 & 2) and actual participants showed significant differences with respect mostly to male role models. These differences were also more prevalent in the home and school than in the workplace. The number of school friends who use computers were significant different for males and females who have taken a computer course. Females who intend to take a computer course knew a significantly larger number of computer using friends than those who did not intend to take a computer course. The males in this category do not show any significant difference.

Students' anecdotal answers to open-ended questions are given in appendix 3. These responses are included to give the reader a better feel for the way in which students view their current or potential participation in computer courses. For the most part they seem illustrative of the significant findings in this study and do not hold any surprises.

Discussion

The overall pattern of computer course participation and intent to participate holds few surprises. The difference in attitudes, interest and participation in computer use seems to be fairly consistent and predictable for both males and females. Only in a few instances do males and females differ on some points. This is perhaps an important consideration because of the generally accepted but not supported claim that some make about differences between males and females.

Students who perceive computers in a positive way are more likely to also be interested in taking a(another) computer course. Students that perceive computers to be useful are more likely to have been enrolled in a computer course. The general attitude toward computers is also more positive for computer students. Self confidence is higher for computer students as well. This is supported in the significant difference in self confidence, perceived usefulness of computers and general attitude scales. The only difference between males and females in attitudes surfaced in the area of sex bias. Males who have participated in a computer class are significantly less biased than those who have not participated. Females on the other hand do not appear to differ greatly in sex bias regardless of course participation. The lower sex bias of males who have taken a computer course is still not as low as females who either have or have not taken a course.

The number of role models for males and females, for the most part, is similar for both genders with a couple of notable exceptions. The data for work role models shows little relationship to participation in computer courses or the intent to participate. This seems to indicate the work place is not particularly important in making course related decisions. The presence of friends who are computer users at home appears to have a differential effect on males. Those with male friends who use computers at home are more likely to be computer course participants and be interested in taking a course. A comparable relationship does not exist for females. There is a male teacher relationship to participation but this may be explained by the high number of male teachers in computer courses. The most consistent finding is the relationship between computer using friends at school and participation. Females show a strong relations between intent to take a course and computer using friends at school. This is not true for males.

Students who have or are taking computer classes when reporting their peer and teacher interactions do not indicate any relation to future course participation. This may indicate that other factors are greater determinants in their decision than the apparent helpfulness of others in class. Their general like or dislike of the computer class was related to this decision. Possible reasons for this feeling were not included in this survey.

Further Study

The differences and similarities between males and females discovered in this study do not solve the question of unequal participation in computer science classes by males and females. It appears that friends in school are a greater influence for females than males in making computer related decisions but with low initial female participation in computer class this trend may be slow to turn around. A more detailed examination of role models with more sensitive instruments would be in order. Personal interviews with high school students may also shed more light on the reasons for this differential participation.

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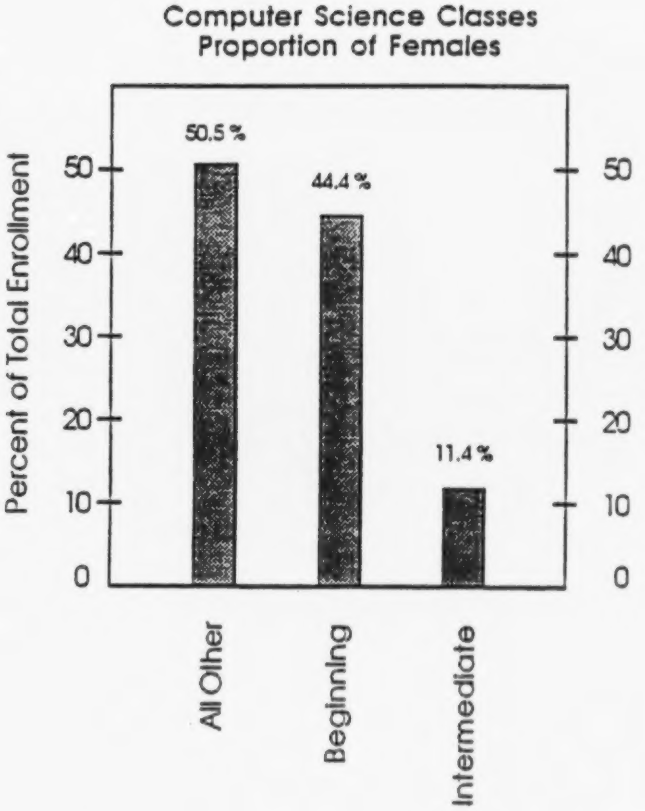
Appendix 1

Chart 1

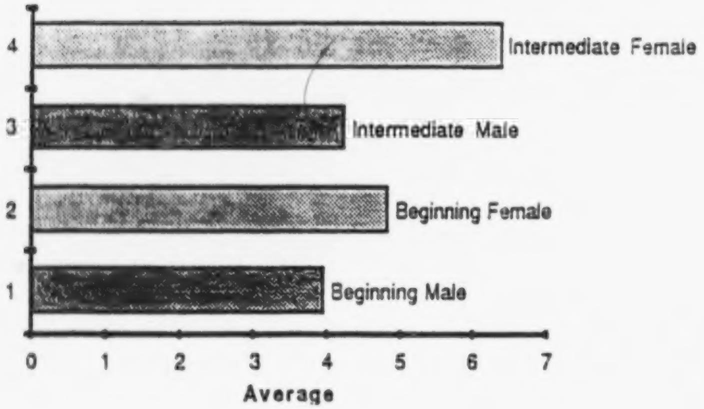


Fall Semester 1987 Enrollment

The percent proportions given are for all computer science classes conducted in the Fall semester of 1987 for four Madison Metropolitan School District High Schools. The 'All Other' catagory represents the proportion of females that are not emrolled in computer science courses.

Chart 2

All Role Models Combined

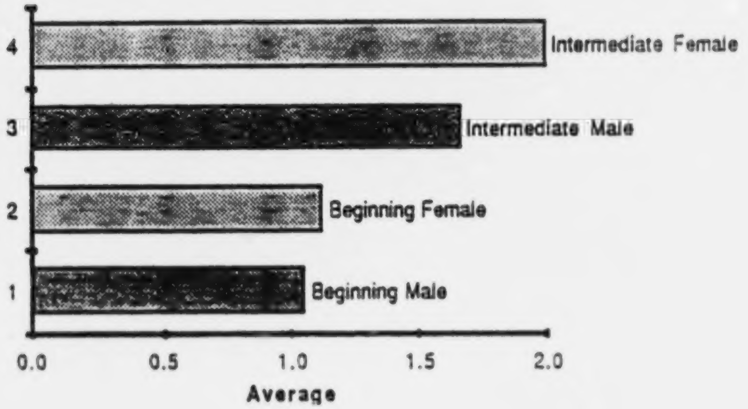


The average number of role models given for home, work and school regardless of role model gender. The averages of role models are given by level of class and gender.

Group	N	Mean	SD
Beginning Male	68	3.96	1.92
Beginning Female	57	4.84	2.40
Intermediate Male	36	4.25	1.57
Intermediate Female	5	6.40	2.30

Chart 3

Male Role Models

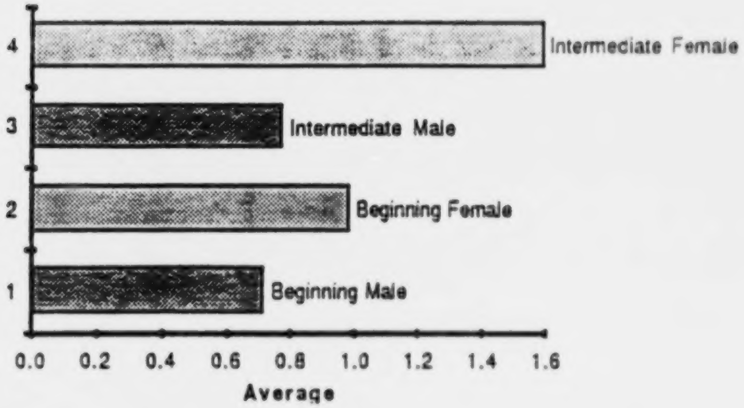


The average number of role models who are males for home, work and school. The averages of role models are given by level of class and gender.

Group	N	Mean	SD
Beginning Male	68	1.06	1.02
Beginning Female	57	1.12	1.18
Intermediate Male	36	1.17	.97
Intermediate Female	5	2.00	1.00

Chart 4

Female Role Models

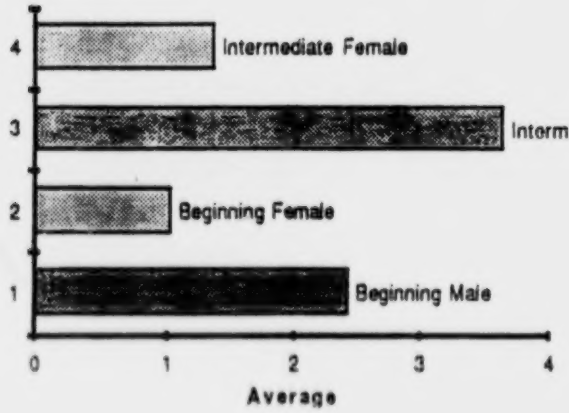


The average number of role models who are females for home, work and school. The averages of role models are given by level of class and gender.

Group	N	Mean	SD
Beginning Male	68	.72	.75
Beginning Female	57	.98	1.09
Intermediate Male	36	.78	.72
Intermediate Female	5	1.60	1.14

Chart 5

Sex Bias

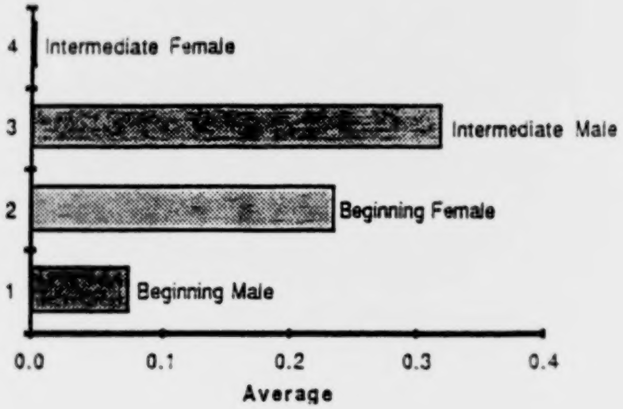


The average total response to three questions on the ability of males and females to do equally well in working with computers. The averages of sex bias are given by level of class and gender.

Group	N	Mean	SD
Beginning Male	68	2.44	2.50
Beginning Female	57	1.05	1.85
Intermediate Male	36	3.67	2.35
Intermediate Female	5	1.40	2.07

Chart 6

Perceived Difference



The average of the perception that there is no difference between males and females in computer use. A score of 0 indicates that there is no difference and a 1 indicates that there is a difference. The averages of perceived differences are given by level of class and gender.

Group	N	Mean	SD
Beginning Male	52	.08	.27
Beginning Female	52	.06	.24
Intermediate Male	28	.32	.48
Intermediate Female	3	.00	.00

Appendix 2

Table 1
Role Models

T-test for the comparison of the number of role models between students who have taken a computer course with those who have not and between those who intend to take a(another) computer course and those who do not intend to take a computer course in high school.

	Taken		Intended	
	Male	Female	Male	Female
WPM	.4188	.5976	.1960	.4858
WPF	.2868	.9270	.6400	.6587
WB	**.0205**	.6761	.1973	na
WS	.8898	.4983	na	.3608
WFrM	.1703	.6309	.6761	.2314
WFrF	.7807	.6821	.8980	.9378
HPM	**.0344**	.2139	.4578	.5028
HPF	.6308	.2832	.6221	.8632
HB	.3610	.3538	.1967	**.0801**
HS	.3315	.6319	na	.8524
HFrM	**.0052**	.6352	**.0942**	.3738
HFrF	.3177	.9025	.6509	.1303
ScTM	**.0000**	**.0005**	.5079	**.0231**
ScTF	**.0576**	.3805	.6974	.8634
SccB	.2965	.3757	.4721	**.0801**
ScS	**.0191**	.2359	.1967	.9030
ScFrM	**.0000**	**.0776**	.2239	**.0696**
ScFrF	**.0000**	**.0206**	.5989	**.0048**

na: SD = 0 for one variable

W - work
P - parent
Fr - friend

H - home
B - brother
M - male

Sc - school
S - sister
F - female

Note: For the purpose of discussion, results that have values less than p = .1000 is considered significant and indicated by bold type. These data may be useful for determining further directions for investigation.

Table 2
Role Models

Pearson R correlation for the comparison of the number of role models between students who have taken a computer course with those who have not and between those who intend to take a(another) computer course and those who do not intend to take a computer course in high school.

	Taken		Intended	
	Male	Female	Male	Female
WPM	.0612	.0485	.1081*	.0753
WPF	.0788	.0030	.0403	.0472
WB	.1669*	.0387	.1083*	.1445*
WS	.0073	.0621	.1733*	-.0972
WFrM	.0987	.0444	.0361	.1258*
WFrF	.0191	.0387	-.0062	.0011
HPM	.1510*	.1113*	-.0643	.0717
HPF	.0253	.0917	-.0428	.0146
HB	.0673	.0838	.1080*	.1812*
HS	.0711	.0440	.1965*	-.0168
HFrM	.2036*	.0432	.1391*	.0957
HFrF	.0731	.0063	.0391	.1572*
ScTM	.4459**	.3223**	.0578	.2346*
ScTF	.1360*	.0793	.0333	.0147
SccB	.0764	.0800	-.0624	.1811*
ScS	.1683*	.1064*	.1083*	.0079
ScFrM	.4352**	.1568*	.1032*	.1877*
ScFrF	.3664**	.2038*	.0455	.2939*

* Slight
** Moderate
*** Strong

W - work
P - parent
Fr - friend
H - home
B - brother
M - male
Sc - school
S - sister
F - female

Note: For the purpose of discussion, results that have values between .1000 and 3.000 are considered slight, between .3000 and point .5000 are considered moderate and those above .5000 are considered strong.

Table 3
After High School Plans

Mann-Whitney test for the comparison of post high school participation in computer related activities.

	Taken		Intended	
	Male	Female	Male	Female
After high school course	**.0000**	**.0180**	**.0545**	**.0128**
Computer science major	.3618	.7432	**.0134**	**.0730**
Computer job	**.0001**	**.0010**	**.0001**	**.0007**

Note: For the purpose of discussion, results that have values less than p = .1000 is considered significant and indicated by bold type.

Table 4
After High School Plans

Spearman R correlation for the comparison of post high school participation in computer related activities.

	Taken		Intended	
	Male	Female	Male	Female
After high school course	.2436*	.2406*	.2222*	.2950*
Computer science major	.0742	.0342	.2336*	.1969*
Computer job	.3460**	.3302**	.4475**	.4304**

*	Slight
**	Moderate
***	Strong

Note: For the purpose of discussion, results that have values between .1000 and 3.000 are considered slight, between .3000 and point .5000 are considered moderate and those above .5000 are considered strong.

Table 5
Attitudes

Mann-Whitney test for the comparison of student attitudes in relation to gender bias, utility of computers, general attitude toward computers and self confidence in the use of computers.

	Taken		Intended	
	Male	Female	Male	Female
Sex bias	**.0635**	.2335	**.0445**	.6564
Utility	**.0004**	**.0001**	**.0000**	**.0001**
General attitude	**.0000**	**.0001**	**.0004**	**.0034**
Self confidence	**.0000**	**.0002**	**.0000**	**.0002**

Note: For the purpose of discussion, results that have values less than p = .1000 is considered significant and indicated by bold type.

Table 6
Attitudes

Spearman R correlation for the relationship of student attitude to gender bias, utility of computers, general attitude toward computers and self confidence in the use of computers.

	Taken		Intended	
	Male	Female	Male	Female
Sex bias	-.1351*	-.1160*	-.1865*	-.1198*
Utility	.2771*	.4092**	.3601**	.3196**
General attitude	.4117**	.3565**	.5565***	.5099***
Self confidence	.5664***	.6766***	.4687**	.4447**

*	Slight
**	Moderate
***	Strong

Note: For the purpose of discussion, results that have values between .1000 and 3.000 are considered slight, between .3000 and point .5000 are considered moderate and those above .5000 are considered strong.

Table 7
Attitudes

Mann-Whitney test and Spearman R correlation for the comparison of student attitudes in relation to how they liked computer class(es), the helpfulness of peers and availability of teachers for assistance between those students who have indicated they would take another computer class and those who would not take another computer class.

	Mann-Whitney		Correlation	
	Male	Female	Male	Female
Liked class	.1358	**.0583**	.3313**	.3407**
Helpfulness of peers	.6182	.4946	.0900	.1366*
Availability of teachers	.8451	.3878	.0517	.2485*

* Slight
** Moderate
*** Strong

Note: For the purpose of discussion, results that have values less than p = .1000 is considered significant and indicated by bold type. Correlation results that have values between .1000 and 3.000 are considered slight, between .3000 and point .5000 are considered moderate and those above .5000 are considered strong.

Table 8
Hours of use

T-tests and Pearson R correlation for the comparison of hours of computer use in relation to participation in computer courses and intent to participate in a computer course.

	Taken		Intended	
	Male	Female	Male	Female
T-test	**.0001**	**.0000**	**.0568**	.2415
Correlation	.3057**	.4581**	.1582*	.1229*

* Slight
** Moderate
*** Strong

Note: For the purpose of discussion, results that have values less than p = .1000 is considered significant and indicated by bold type. Correlation results that have values between .1000 and 3.000 are considered slight, between .3000 and point .5000 are considered moderate and those above .5000 are considered strong.

Appendix 3

APPENDIX 3

1: female

Why haven't you taken a high school computer course?

"I don't understand them and I am afraid to flunk. Computers are for smart people."

Would you take a computer course in high school if possible?

"Yes, if I thought the teacher could teach it to me."

Make any additional comments concerning computer courses.

"I'd like to learn. It is not like I hate them. I would not mind sitting behind a computer for 8 hours a day. I hope I will understand them more someday."

2: female

Why haven't you taken a high school computer course?

"Because I don't like computers. They are confusing and smarter than I am, and I don't understand how to use them."

Give your thoughts about: some people think that it is difficult to learn to use computers.

"Yes, it is. The computer is smarter than you and it makes you feel stupid when you did not do something right."

3: female

Give your thought about: some people think that it is becoming increasingly important to know how to use the computer.

"It is and that is not good because they will over run the world."

4: male

Make any additional comments concerning computer courses.

"Courses should be less lecture and more hands on type work. Lectures could be given in the lab so the students can see how the work is applied first hand."

5: male

Make any additional comments concerning computer courses.

"I'd take some more classes if they were available."

6: female

Why haven't you taken a high school computer course?

"Because I don't have a computer at home. I don't have any use to yet."

7: male

Give your thought about: some people think that it is difficult to learn to use the computer.

"Yes, it is, if you don't have a good teacher."

8 : female

Make any additional comments concerning computer courses.

"There should be a class just for typing like on an every other day basic for only like a half hour schedule. Because I don't want a computer major, I want to know how to type."

9 : female

Why haven't you taken a high school computer course?

"I don't like working with computers and it is too much like typing."

Give your thought about: some people think that there is a difference between males and females in how they feel about computers.

"It seems like guys think that using a computer is uncool, but girls are a little more open-minded."

10 : female

Why haven't you taken a high school computer course?

"Because there are other important classes that I need to take."

11 : female

Give your thought about: some people think that it is becoming increasingly important to know how to use the computer.

"For people who are not willing to learn, that can be difficult. Otherwise it is very easy to learn."

Appendix 4

Computer Survey

Page 1

Circle the letters that most closely match how you feel about each statement.

SD - Strongly Disagree D - Disagree NO - No Opinion A - Agree SA - Strongly Agree

1.	I would like to own my own computer.	SD	D	NO	A	SA
2.	Working with a computer makes me want to learn.	SD	D	NO	A	SA
3.	I learn a lot with a computer.	SD	D	NO	A	SA
4.	Being able to work with a computer is important.	SD	D	NO	A	SA
5.	I like to use a computer.	SD	D	NO	A	SA
6.	I like using computers in school.	SD	D	NO	A	SA
7.	I enjoy making a computer do what I want.	SD	D	NO	A	SA
8.	I don't like working on a computer.	SD	D	NO	A	SA
9.	Computers are a tool just like a hammer or saw.	SD	D	NO	A	SA
10.	Using a computer is a waste of time.	SD	D	NO	A	SA
11.	Using computers is more for boys than for girls.	SD	D	NO	A	SA
12.	People don't need computers.	SD	D	NO	A	SA
13.	I enjoy using the computer.	SD	D	NO	A	SA
14.	Computers are more for boys than girls.	SD	D	NO	A	SA
15.	I am good at running a computer.	SD	D	NO	A	SA
16.	Girls do just as well as boys in computer jobs.	SD	D	NO	A	SA
17.	I don't work well with computers.	SD	D	NO	A	SA

Computer Survey   Page 2

Please circle: Grade 9 10 11 12

Age 14 15 16 17 18

Sex Male Female

Estimate the average number of hours per week that you use a computer at:

Home _____ School _____ Work _____ Other _____ Where?

A Answer questions in this section if you have *not* taken a computer course.

Why haven't you taken a high school computer course?

Would you take a computer course in high school if possible? yes no don't know

Please Explain.

B Answer this set of questions if you have taken a computer science course.

How many high school computer science courses have you taken (including current)? _____

Please list.

Circle the work or phrase that best describes your previous computer science course(s)?

I (liked, disliked) my previous computer science classes.

Classmates were (helpful, not helpful) when I needed help with assignments.

My computer teacher was usually (available, busy) when I needed help.

Would you take another computer course in high school if possible? yes no don't know

Please Explain.

C **Please answer all questions.**

After high school, will you take a computer course(s)?	yes	no	don't know
Do you plan to major in computer science in college?	yes	no	don't know
Would you like a job working with computers?	yes	no	don't know

Check the people that you personally know who use computers at work, home or school:

	Parent/Guardian				Friends	
	Male	Female	Brother	Sister	Male	Female
Work	____	____	____	____	____	____
Home	____	____	____	____	____	____

	Teachers				Friends	
	Male	Female	Brother	Sister	Male	Female
School	____	____	____	____	____	____

Please give your thoughts about the following statements:

Some people think that there is a difference between males and females in how they feel about computers.

Some people think that it is difficult to learn to use the computer.

Some people think that it is becoming increasingly important to know how to use the computer.

Thanks for your cooperation in answering the questions on this survey. Please make any additional comments concerning computer courses that you would like on this page.

Title:

The Durability of Picture Text Procedural Instructions for Individuals with Different Cognitive Styles

Authors:

Dennis Ausel
George R. Bieger

The Durability of Picture Text Procedual Instructions for Individuals with Different Cognitive Styles

by

Dennis Ausel
George R. Bieger

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The Durability of Picture Text Procedural Instructions for Individuals with Different Cognitive Styles

by

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INTRODUCTION

Picture text instructions are often used to guide learners through a variety of tasks. These tasks range from assembling a lawn mower to operating a power plant. Past research indicates that the addition of pictures to text while the users have the instructions at hand, improves the comprehension of the instructions (Crandell, 1979; Bieger & Glock, 1982; Stone & Glock, 1981. Sometimes, however, the instructions are not at hand and the learner has to rely on his/her memory of the instructions. If the situation is life threatening, recall of the instructions may be critical. Recent research indicates that the addition of pictures to text improves recall of factual information (Anglin 1986; Rasco, Tennyson and Boutwell, 1975) however, no research could be found which indicated whether or not the addition of pictures to text aided in the recall of assembly tasks.

Another variable which might come into play is the learner's cognitive style. Some learners with certain cognitive styles may better at immediate comprehension and delayed recall than other learners with different cognitive styles. In addition their may be an interaction of cognitive style and picture/text formats.

PURPOSE OF THE STUDY

More specifically, the propose of this research project was to examine whether or not the addition of pictures to text will produce significantly better recall when the instructions are not available. In addition the study also examined the effects of cognitive style and the possible interactions on both immediate comprehension and delayed recall.

STIMULI

Three sets of procedural instructions for a model hand cart were employed. One set was sequential pictures alone, the second set was text alone and the third set was a combination of the sequential pictures and the text. All three sets of instructions had been employed in previous experiments and had been found effective.

COGNITIVE STYLE

Ninety student undergraduates were given the Group Embedded Figures Test. Twenty-five of the individuals identified as field independent and twenty-five of the individuals identified as field dependent were asked to participate in the experiment. Of the fifty individuals, forty-seven were able to participate.

PROCEDURES

The forty-seven undergraduates who were classified as either field independent or field dependent were randomly assigned to one of the three sets of procedural assembly instructions (i.e. text alone, pictures alone or pictures plus text). The learners were tested individually.

Individually,each participant was asked to assemble the model loading cart while the assigned instructions were at hand. Individuals who assembled a hand cart which was judged functional were asked to return 28 days later to reassemble the model without the instructions. Two dependent variables were employed(time on task and assembly errors) for the immediate comprehension task and the delayed recall conditions.

RESULTS

Assembly procedures were subdivided into two categories; those critical to the construction of a "functional" loading cart, and those not critical to the construction of a "functional loading cart.

A 3 x 2 x 2 ANOVA was conducted to examine the effects of Cognitive Style (Field Independent-Field Dependent), Stimulus Type(Picture Alone, Text Alone, Text with Picture), and Gender (Male-Female) on performance, using accuracy scores and assembly times for critical sub-assemblies as the dependent variables.

Those subjects presented with Text Alone were significantly less accurate on critical subassemblies than were subjects who received either the Pictures Alone or Text with Pictures (Text Alone - 13.50, Picture Alone - 15.47, Text with Pictures - 16.00). There were no other significant main effects or interactive effects pertaining to accuracy on critical subassemblies.

On the non-critical subassemblies there were no significant differences for any of the main effects, nor were there any significant interactions.

Subjects differed significantly in the total time needed to complete the assembly depending on which set of instructions they received and as a function of their cognitive styles. Subjects using the Picture Alone instructions completed their assemblies fastest (11.21 minutes), with those receiving Text with Pictures performing significantly slower (12.67 minutes), and those using the Text Alone being significantly slower still (13.75 minutes). Field-Independent subjects completed their assemblies significantly faster (10.61 minutes) than did those who were Field-Dependent (13.47). There were no significant differences between males and females, nor were there any significant interactions.

Those subjects who completed "functional" loading carts were asked to return for a second session one week after the initial assembly session. At the second session subjects were asked to perform the assembly again without use of any instructions at all. As in the initial part of the study, time of assembly and accuracy on critical subassemblies were examined as dependent variables in the Recall part of the study. These measures of performance were examined for differences attributable to Cognitive Style, original Stimulus Type, and Gender.

Field-Independent subjects performed significantly more accurately on the critical subassemblies than did Field-Dependent subjects (12.83 vs. 8.53). There were no other significant main effects or interactive effects pertaining to performance accuracy. As expected, accuracy scores in the Recall phase of the study were generally lower than in the first part of the study.

Subjects differed significantly in the total time needed to complete the assembly during the Recall phase, depending on which set of instructions they had received in the first session. Subjects who had used the Text Alone instructions completed their recall assemblies fastest (10.75 minutes), with those having used the Picture Alone performing significantly slower (16.42 minutes), and those having used the Text with Picture instructions being significantly slower still (20.42 minutes). There were no significant differences as a function of cognitive style in recall times nor were there significant recall assembly time differences between males and females.

There was a significant two-way interaction between Stimulus Type and Cognitive Style, however this interaction was judged by the researchers to be due largely to one extremely fast assembly.

DISCUSSION

The results summarized above indicate that, at least for this task, the type of instructions (Text, Picture, or Text with Picture) can produce significant differences in accuracy of performance, but that the effects on accuracy of the type of stimulus are not long-lasting. Conversely, while cognitive style did not produce significant differences in performance accuracy in the short-term, successful assemblers who were Field-Independent retained their assembly knowledge better than their Field-Dependent counterparts.

With respect to speed of assembly, the effects of stimulus type are more complicated. In the short term, pictures alone seem to produce faster assemblies and text alone the slowest. However, in the long term, text alone produced faster recall assemblies.

The differential effects of stimulus type and cognitive style on both initial performance and longer term recall are worthy of continued examination in future research.

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Title:

Integrating Instructional Technology in Educational Institutions: The Proper Role for Teachers

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Integrating Instructional Technology in Educational Institutions: The Proper Role for Teachers

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Integrating Instructional Technology in Educational Institutions: The Proper Role for Teachers

Ronald Aust, Gary Allen and Barbara Bichelmeyer
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In his article, *The Proper Study of Instructional Technology*, Robert Heinich (1984) pointed out that the evolution of instructional technology has been hampered by its historical roots in training teachers to operate and apply instructional tools within the limited confines of existing educational systems. Many educational institutions are bound by the continuation of an equipment-training mentality, even though today's user friendly media and computers require much less training to operate than the manually adjusted media and mainframe computers of yesterday. Heinich (1985) further contended that there are forces within educational institutions that perpetuate the craft nature of teaching and limit the development of those instructional technologies which could be viewed as threats to the teachers' power structure. He recommended that researchers should investigate the nature of these forces and devise strategies for expediting more widespread application of instructional technology.

In current educational environments, teachers and trainers are most comfortable when they are allowed to control the practice of their craft in the classroom. As long as teachers view themselves as authorities in developing, selecting and using instructional support materials, their power structure remains intact. But as applications of instructional technology result in more self-sufficient lessons, which are in turn embedded in more precisely specified systems of instruction, many teachers may become less effective because they fear that their contribution to the learning process is diminishing.

Who should be first to encourage the integration of instructional technology?

Heinich has identified existing conditions in educational institutions which must change if the benefits of instructional technology are to be fully realized. The issues and potential impact on students, teachers, and teacher educators are substantial. Remedies must be chosen carefully. We can, as Heinich has suggested, attempt to address these issues at the institutional level by encouraging administrators and government policymakers to re-examine educational institutions and adopt cost-effective instructional systems which incorporate electronically-mediated courses. But, even if such efforts are successful, the sudden appearance of a number of legislated electronic courses will not go unchallenged. And, these challenges may only serve to ingrain the craft role of teachers and trainers.

In a point-of-view statement which appeared in *The Chronicle of Higher Education*, David Grossman (1987) attacked the incorporation of electronically-produced external courses. Among other criticisms, he argued that such courses: are often inferior to those which would be used by the institutions that export them, separate faculty from course development, trivialize education, and threaten the vitality of the university by encouraging a homogenization of instruction. Whether or not one agrees with Grossman's position, the political explosiveness of such statements must not be underestimated.

Allan Bloom (1987) has criticized the current structure of American universities for creating an anarchy of specialized disciplines that undermines the foundation of liberal arts education. Evidence for this anarchy is apparent in the way that departments within universities are becoming more specialized both in terms of course offerings and resources. Bloom and other educators are concerned that, while this narrowing of curricula and the specification of resources may prepare the student for short term job opportunities, it is ultimately crippling their abilities to reason in ways that will allow them to adapt to inevitable life changes encountered in a complex society.

In light of the current social climate toward education, a large-scale strategy of lobbying administrators and legislators to incorporate a wide range of mediated courses could very well backfire in the form of a rising tide of criticism toward instructional technology. The problem is that, despite the need for change, a critical mass of popular support is required before revolutionary changes will be successful in social institutions. Consider the policies and institutional restrictions which led to the United States' involvement in Vietnam. The central thesis of Colonel Harry Summers' (1982) critical review of strategies applied during the Vietnam war was that "...a lack of appreciation of military theory and military strategy - especially the relationship between military strategy and national policy - led to a faulty definition of the nature of the war. The result was the exhaustion of the Army against a secondary guerrilla force and the ultimate failure of military strategy to support the national policy of containment of communist expansion (p. VII)."

Summer further explained that one of our greatest errors was to allow U.S. Forces to be involved in the internal struggle of Vietnam politics and pacification. At a time when the Vietnamese people were leaning toward a democratic form of government, the infusion of U.S. troops to fight *their war* only served to alienate the populace, ultimately resulting in greater acceptance of Communism. Summers believed that a more appropriate strategy would have been to seal off the borders of Vietnam, thereby preventing the entry of unstabilizing elements and establishing an environment in which the Vietnamese could bring their internal struggle to a close.

The point in this analogy is that without popular support from teachers who clearly understand the benefits of instructional technology, attempts to force the use of electronically-mediated instruction in educational institutions could be disastrous. The results could be the same as those experienced in Vietnam. In the education scenario, the secondary guerilla force that experiences disparate victory would be the teachers who maintain their craft status. This unseemly scenario would only impede the acceptance of instructional technology while failing to serve the best interests of both teachers and learners.

Teacher Attitudes of Instructional Technology

A long term strategy for integrating instructional technology should be one of winning support at all levels that influence the structure of educational institutions. In order to accomplish this, the potential for conflict must be recognized and averted as the involved parties begin to posture and negotiate their positions (Frost and Wilmot, 1978; Jandt, 1973). Anderson (1980) pointed out that instructional materials which have not been influenced by teacher input have a history of vanishing due to lack of teacher interest or commitment. And in an analysis of factors that influence the success of computer-based training (CBT), McCombs (1985) determined that the processes of defining instructor roles during implementation and the maintenance of student/instructor interactions was critical in assuring the success of CBT. She also claimed that this process must be done actively with the instructors in order to gain their confidence. Once a critical mass of teachers advocate the use of instructional technology, Heinich's advice of lobbying the governing bodies can take place in an atmosphere of coalition rather than conflict. The logical extension is that as the base of support grows from within the educational institutions, the favorable climate will help to increase acceptance and bolster the evolution of instructional technology.

This study investigates the nature of teachers' attitudes toward the integration of instructional technology. Our intent is to shed light on the social and psychological factors which contribute to teacher acceptance and/or rejection of instructional technology. Once these factors are more completely understood, they may serve as guides for curricula decision making, instructional design strategies and the evolution of institutional policy.

Method: Naturalistic Inquiry

Because the components of teachers' belief structures were unknown and highly subjective, a naturalistic paradigm was used as the guiding research design. The naturalistic methodology is an emergent design which is particularly useful in studies where the definition of issues is vague at the outset, and researchers are interested in revealing the parameters of the issues and the factors effecting those issues. The naturalistic inquiry adheres to the rigor of tandem data collection techniques. Specifically, this meant the use of structured interviews and the factor analysis of an attitude response form. Guba, (1981) encouraged the combination of a rationalistic approach (attitude scale) with a naturalistic approach (interviews) in qualitative research.

The interview phase of the qualitative analysis began with the following assumptions:

1. The data would be value-laden because they are based primarily on the belief structures of educators, rather than on facts gathered by empirical research.

2. Multiple realities would be expressed by the various educators, in that their views about the need for and use of technology in the classroom would include a number of varying beliefs and opinions.
3. Through verbal communication, the human can be a legitimate instrument for data collection.
4. During the interview phase of the research, a small, purposive sample would be acceptable because replication of data was the criterion to be achieved.
5. Boundaries of the interviews were determined by the focus on factors which influence the acceptance and/or rejection of instructional technology.
6. Data from the interview stage of the research would be used to create a comprehensive set of items as a basis for developing the attitude scale.
7. Factor analysis of the attitude scale would be used in considering the appropriateness of the categories identified through the interviews.

The interviews

Five professional public school educators with varying numbers of years of experience and different content area expertise were interviewed. Each interview lasted approximately 30 minutes and was conducted following a similar outline. The number of interviews conducted in this phase of the study was determined by the amount of replication of data collected in each of the interviews.

At the beginning of each interview, educators were asked to fill out a consent and demographics form that identified: number of years of teaching experience, grade levels taught and types of technology used for professional purposes.

After the educators completed the demographics form, a few minutes were spent with introductions and getting acquainted. The introduction concluded as the interviewer stated the purpose and procedure for the remaining portion of the interview. The interviewer stated that the reason for the interview was to get ideas from the educator about how he or she felt instructional technology should be used in the classroom.

At this point, the educator was asked to define his or her concept of instructional technology. This step was included in the interview process to make sure that both the interviewer and the educator had a similar understanding of the general concept of instructional technology before proceeding with any further investigation of the educator's beliefs about its value and use in the classroom. The working definition of instructional technology used for this study was: "The discipline of creating, evaluating and disseminating educational materials through various forms of media including (but not limited to): sound-slide shows, overhead projections, bulletin boards, television, films and computers." If an educator would have given a definition that did not adhere to the working definition, the interviewer would have suggested a definition more closely suited to the working definition. However, this logistical problem did not arise during the interviews.

The main portion of the interview consisted of seven questions, which were asked in the same order to each of the educators. The questions were:

A) In your professional situation, how do you typically use instructional technology?
B) What are the advantages of using instructional technology?
C) What are the disadvantages of using instructional technology?
D) What are the differences between teachers who don't use instructional technology and teachers who do?
E) In your picture of the ideal situation, what types of instructional technology would be available to you to help you reach your students?
F) As more sophisticated types of instructional technology become available, what do you imagine the role of the classroom teacher will be in the future?
G) What is your opinion about the role teachers should take in designing instructional technology and why?*

* This question was prefaced with the explanation of the following debate: *There is a debate in education today about the role that teachers should take in designing fully mediated instruction. Some people say that teachers should be the principal designers of software and materials to be used with instructional technology, because they are the ones who work most closely with students and they are most aware of students' needs. There are others who think that instructional software and materials should be developed by full-time instructional designers and that a teacher's role should not be as a developer of instructional materials but as one who implements the instructional designers' products in the classroom environment.*

Analysis of the interviews

Based on the data collected in the interview phase, categories were created to reflect these educators' expressed sentiments about instructional technology. After each interview was completed, data from the interview were chunked into separate topic categories and each unit of data was placed on a 3"x5" note card with a numerical code that identified the source of the data, and a working title to denote the type of data on the card. After the completion of all interviews, cards were sorted into categories of similar data, and names were developed for each unit of similar data. The categories were called factors and opposing positions were identified within each factor. The factors identified were:

Entertainment value represents the belief that fully mediated instruction is primarily entertainment and therefore non-educational. The opposing belief is that students learn a considerable amount from fully mediated instruction because they are interested in what they observe.

Teacher displacement represents the belief that teachers' classroom duties will be displaced by instructional technology. The opposing belief is that instructional technology will continue to be a tool, albeit a more advanced one, for teachers to utilize in their classrooms.

Need for innovation acknowledges that, due to differing personality traits, some teachers want to be at the forefront of educational change. The opposing belief is that many teachers are comfortable with the status quo in education.

Decline of the printed word represents the belief that instructional technology is contributing to the loss of the written word. The opposing belief is that instructional technology merely emphasizes different critical thinking skills for processing information.

Intransigent factor is based on the belief that certain (often described as older) teachers are set in their ways and less willing to experiment with advances in instructional technology.

Teacher control is based on the belief that the teacher should dominate the classroom and dictate lessons to students. The opposing belief is that the teacher is viewed as a facilitator who helps students to become independent learners and to make their own decisions.

Dehumanization represents the belief that instructional technology is mechanized, dry, inflexible and unresponsive to students. The opposing belief is that instructional technology produces a more thoroughly thought-out and systematic approach to lessons than any single teacher can and therefore better meets the needs of individual learners.

Content specific refers to the belief that some content areas are appropriate for use of instructional technology while many others are not. The opposing belief is that all content areas can benefit in some way from using instructional technology.

Techno-literacy represents the belief that some teachers are naturally more comfortable with using technical equipment to aid instruction. The opposing belief is that many teachers do not understand how technical machines work and that they should not be forced to learn about them.

Prepare for the future is the belief that instructional technology should be a primary consideration in school expenditures because it is the wave of the future. The opposing belief is that instructional technology should be a secondary consideration because it is futuristic and educators need to concentrate on meeting the needs of students today. (This factor was based on the question of allocation of monetary resources.)

Inadequate software refers to the concern that instructional technology is not ready for integration into classrooms because there is not much effective software available. The opposing belief is that instructional technology is ready for the classroom just as soon as teachers are willing to make the effort to design programs for their own particular needs.

Limited time represents the assumption that, given limited time and resources, teachers should spend their energy working with students. The opposing belief is that, given limited time and resources, teachers should attempt to make lessons as creative, interesting and understandable as possible, and use of instructional technology can aid this process.

Development of the survey instrument

After the initial review of the interview reports and categorization of factors, the first draft of the survey was developed according to the guidelines described in the *Survey Questions: Handcrafting the Standardized Questionnaire* (Converse and Presser, 1986).

A panel of three experienced educators who were familiar with the study and results of the interviews assembled to create the items for the initial draft of the survey. Each member worked independently to write 10 Likert scale items for each of 12 different factors that were identified from a pattern analysis of the interview information. The items were assembled and produced as a numbered list of items. This list of numbered items was then independently reviewed by each member of the panel. The panel met again as a group to review the independent critiques and agreed on the final list of 120 items. Finally, the order that the items would appear on the test form was determined using a random number generator and the version of the survey that was used in this study was produced.

The Teacher Attitudes of Instructional Technology (TAIT) survey included 10 items for each of the 12 factors identified during the interviewing phase. Responses to each item are marked on a 5-point Likert scale. A response of 1 indicates strong agreement with the statement, 3 is a neutral response and 5 indicates strong disagreement. A majority of the items (81) directly referred to opinions about the use of fully mediated instruction. Directions on the first page of the TAIT survey included definitions for the following terms:

Instructional Support Media -- Educational materials which are used by teachers to present ideas. These includes overhead transparencies, films, television programs, slides and computer software when the materials are used to assist the teacher in delivering lessons.

Fully Mediated Instruction -- Lessons or courses which are presented by media without any required assistance from a teacher. These include courses which are delivered entirely on television or computers. Fully mediated instruction is distinct from instructional support materials because it is designed so that it can be used without any intervention from a teacher.

Administering the TAIT Survey

The survey was administered during the beginning sessions of graduate education courses held during the 1988 Summer and Fall semesters at the University of Kansas. Observers explained that responses would be anonymous and that completion of the surveys was voluntary. The subjects were asked to review the directions, paying special attention to the definition of terms. After responding to appropriate questions pertaining to the directions or definitions, the observer instructed the subjects to complete the survey.

Of the 146 subjects who completed the survey, 36 were males and 110 were females. The graduate education students represented a broad range of educators, including those prepared for both elementary and secondary levels, a variety of content areas and international education.

Factor Analysis

The objective of a factor analysis is to reduce a large set of variables to a smaller set categories or factors that reflect the observed results (Anderson, Basilevsky, Hum, 1983). The Handbook of Survey Research (Rossi, Wright, and Anderson, 1983) was used to begin the process of reducing the initial set of 120 items down to a manageable number. The SPSSx statistical package was used in adhering to the following procedure described by Bohrnstedt (1983, p.102).

1. Conduct an exploratory factor analysis using the Maximum Likelihood procedure.
2. Decide on the number of factors needed to explain the covariation among the items using both the X^2 and Tucker-Lewis statistics for reference.
3. Examine the Eigen values of the rotated and unrotated solutions when $m > 1$ in order to determine if the items are meaningful or unwanted.
4. Remove the items that are poorly related or represent more than one domain.
5. Use a confirmatory analysis (Varimax) to refactor the remaining items to verify that they are congeneric.

Results from the TAIT Survey

The factor analysis resulted in the identification of five prevalent factors that concern the use of fully mediated instruction. After reviewing the items that were correlated with each factor, a representative title was established for each factor. Some items were recoded so that the factor means would accurately represent opinions towards the concept expressed in the factor's title. For example, one of the items that correlated with Teacher Involvement (factor four) was -- *The initiative to use fully mediated instruction should come from teachers* (M=2.16), and another factor four item was, -- *The main reason that some teachers don't use fully mediated instruction is because they are too lazy to make the effort* (M=3.93). In this case, the second item was recoded so that the 1 responses (strong agreement) became 5s (strong disagreement), the 5 responses became 1s and so forth. Recoding of the second item in determining the factor four mean served to more accurately reflect the opinions regarding the willingness of teachers to become involved in using fully mediated instruction. Correlations for the items associated with these five factors ranged from .38 to .84. Following is a list of the factors and representative survey items for each factor:

1. ***Curriculum Content*** (M=2.21, SD=1.09). On the 5-point scale, teachers agreed that curricula content areas like math and reading can be effectively taught using fully mediated methods. However, this belief varied somewhat between content areas. For example, there

was agreement that, *English is an appropriate content area for fully mediated instruction* (M=2.7, SD=1.3), but there was even greater agreement with the statement that, *Math is an appropriate content area for fully mediated instruction* (M=2.2, SD=1.2).

2. ***Extension of traditional methods*** (M=2.17, SD=1.15). The findings indicated an acceptance of the belief that fully mediated instruction can successfully augment traditional methods of instruction. For example, there was disagreement with the statement, *Fully mediated instruction does not coexist well with traditional educational methods* (M=3.71, SD=1.07). And, this notion correlated with the belief that *Fully mediated instruction should go beyond the scope of individual lessons* (M=2.18, SD=1.04).

3. ***Integration of Instructional Technology*** (M=1.63, SD=.93). This factor addresses teachers' beliefs about how instructional technology can be used to augment instruction and who should be involved in its development. The findings indicate strong support for the belief that integration with other classroom teaching techniques is the answer. The greatest agreement among all items was to the statement: *Instructional support media compliments the teacher's role in educating students* (M=1.45, SD=.65). And, this group of educators would like to be involved in implementing integration. -- *I would be willing to integrate instructional support media into my lesson plans* (M=1.57, SD=.73).

4. ***Teacher Initiative*** (M=2.1, SD=1.01). This factor expands on the notion that educators are willing to be involved in the integration of instructional technology. A reasonable explanation for educators' expressed belief that, *The initiative to use fully mediated instruction should come from teachers* (M=2.16, SD=.96), is that, *Teachers have more faith in instruction of their own design* (M=2.19, SD=1.0).

5. ***What Does the Future Hold*** (M=2.52, SD=1.10). As the title of this factor implies, some soothsaying is needed here. Those subjects who agreed with the statement that, *Few teachers will be displaced by fully mediated instruction in the future* (M=2.38, SD=1.1) also tended to agree with the statement that *Fully mediated instruction is a more systematic approach to instruction than traditional classroom instruction* (M=2.65, SD=1.09). Is this a belief that traditional instruction needs to become more systematic? A condemnation suggesting that instructional technology is impersonal? A realization that certain aspects of instruction need a highly systematic approach which can be best served by instructional technology? Or, is it a reflection of the uncertainty of what lies ahead for instructional technology and the careers of educators?

Conclusions:

Naturalistic research methodology was useful in revealing the dimensions of the belief structures through which teachers form opinions about the development and use of instructional technology. Our initial subjective notions were expanded through the interview sessions, which were the basis for the formation of the first set of categories. Analysis of the survey provided a means of sampling a larger pool of the population and resulted in a recasting of some earlier formed categories.

The general conclusion is that most educators are excited about applying instructional technology in the classroom and that they want to be involved in both the development and application phases. Results from the sample used for this study did not suggest an undercurrent of resistance toward instructional technology. However, this conclusion should be tempered by a recognition that the sample consisted of educators who had elected to pursue graduate education, and most of the participants lived near a major university or a large metropolitan area. A broad sampling of classroom teachers in both rural and urban districts may reveal somewhat more tentative opinions toward instructional technology.

For the most part, the belief categories determined by the factor analysis confirmed assumptions about the contributing factors drawn from the interviews. Opinions that instructional technology is more appropriate for some content areas, e.g. Math and Science, than others, e.g. English, prevail. Although there are different levels of agreement, educators appear to believe that the use of instructional technology is appropriate for all content areas.

When asked the question, *How should instructional technology be brought into the curricula?* the overwhelming response is *through integration.* Teachers seem to recognize that fully mediated instruction has the potential to deal with a broad base of curricula content and they believe that it is best used in conjunction with traditional approaches to teaching. They appear to be convinced that computers and other informational technologies will continue to shape all aspects of society and they want to play significant roles in preparing students with the necessary skills for adapting to the technological changes which are sure to come in the future.

Teachers express a willingness to extend the effort necessary for learning how to develop and apply instructional technology. However, they are concerned that they don't have enough time to learn all they need to know. And, they will strongly oppose efforts to channel teacher salary funds to the development of instructional technology. Out of the 120 items in the TAIT survey, the greatest disagreement (M=4.37, SD=.95) was to the statement, *Some of the money now designated for teacher's salaries should be spent on acquiring good fully mediated instruction.* Teachers are willing to extend the effort necessary to apply instructional technology in their teaching but when it comes to their salaries, hands off.

Recommendations

Teachers are the foundation of our educational institutions. They shape the instruction and activities in the classroom and they are role models for our students. Instructional technology will not reach its full potential without their support. Some who ponder the future of educational institutions in light of instructional technology (Heinich, 1985; Perlman 1988) believe that a restructuring of the systems will be needed before any significant advances are realized. Revolutionary changes may be needed, but such changes must be sensitive to the needs and aspirations of teachers. As Heinich emphasized, even well-designed instructional technology can be sabotaged by a disinterested teacher.

The reason that teachers strongly disagree with statements regarding the use of teacher salary funds for instructional technology may have more to do with their dignity than their pocketbook. Strategies for incorporating and training in the use of technology must empower the teachers in ways that give them a sense of control over their own destinies (Frymier, 1987; Grady 1988; Maeroff, 1988). Teacher education programs should include required courses which focus on topics for integrating instructional technology throughout grade levels and content areas - not those that are restricted to programming or production techniques (see for example Bruder, 1989; Rossenberg, S.& Bitter, G. (1988)).

Teachers should also view themselves as active participants in the evolution of instructional technology. One way to empower teachers is to provide greater teacher control features in instructional software. The teachers in this study strongly agreed that, *Educational software should be designed to allow for modifications by teachers* ($\underline{M}$=1.64 $\underline{SD}$=.88). Interactive courseware should be designed to allow teachers to control such features as time, difficulty level, feedback, questions and certain aspects of content.

An open environment for exchanging ideas between teachers and developers of instructional courseware should be developed. Consider how the introduction of the personal computer has changed attitudes toward the application of technology to management problems encountered in business and industry. The roles of millions of professionals have gone through significant changes as the result of computerizing the workplace. In many cases, these changing roles are being adopted with enthusiasm, not antagonism. Secretaries who have experience with word processors are not requesting that their typewriters be returned.

In some business applications, personal computers are simply tools for assisting workers in more efficiently accomplishing existing aspects of their job, such as word processing. They serve in much the same way that media tools serve the craft nature of teaching. However, as personal computers begin to appear on the desks of middle management, a much broader impact on business institutions is emerging in the form of technological approaches to problem solving (Scully, 1987).

The middle manager's romance with personal computers began with recognition of the power of databases for keeping track of employees and spreadsheets for controlling accounts. But recently, middle managers are beginning to use project management and advanced spreadsheet software for decision-making, long-term planning and forecasting. In this way, the personal computer has acted as a conduit through which more systematic procedures are applied to solving the complex problems that successful business must overcome as they enter the information age. As more advanced and more user-friendly authoring software becomes available to educators, the personal computer may serve a similar function in educational institutions by developing a broader acceptance of instructional technology.

If David Pearlmen's (1988) prognosis for the future of educational institutions is realized, there will be new and expanded educational opportunities in such disciplines as learner analysis, courseware development, home or rural-based distance learning and educational evaluation. The obvious candidates for these new positions come from the ranks of those who are currently teaching in our schools. Mechanisms for allowing teachers to develop instructional technology should not come only from universities, there must be a greater emphasis on professional development from school systems and from state education offices. When teachers also become developers, they are likely to take a more personal interest in the quality of instructional technology and thereby become more conscientious critics. Educational institutions can then focus on their primary task, and become places where teachers are united in efforts to apply instructional technology to the enhancement of learning throughout the curricula.

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Title:

An Eclectic Qualitative-Quantitative Research Design for the Study of Affective-Cognitive Learning

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An Eclectic Qualitative-Quantitative Research Design for the Study of Affective-Cognitive Learning

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An Eclectic Qualitative-Quantitative Research Design for the Study of Affective-Cognitive Learning

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Whenever a research question or set of questions calls for investigation of complex phenomena there is the distinct possibility that no single research technique will provide a clear answer or set of answers. Experimental research designs generally call for the isolation of discrete variables and proceed from there through appropriate data collection and manipulation routines leading to results upon which we can place a high level of confidence. Usually when we wish to explore the interactive relationships of two variables we simply stabilize one variable and manipulate the amount of variation of the other -- all the while observing the results. When we begin to operate in three or more variables, however, that simplistic dependent variable vs independent variable approach breaks down. In effect, for three variables we have at least two and possibly three dependent vs. independent comparisons. For four or more variables, the number of potential two-variable comparisons increases geometrically as the number of total variables increases (the sequence is 1, 3, 6, 10, 15, 21, 28, etc.). And each additional two-variable comparison that is to be investigated warrants consideration for unique experimental and/or data collection treatment. Of course none of this is new to research scholars, but the impact of running what amounts to several concurrent, but procedurally different experiments tends to mitigate against examination of multi-variable questions unless similar and compatible procedures are contemplated.

Occasionally, though, more than two dissimilar variables cry out to be investigated together. This paper describes a research design for considering the effects of visual and verbal variables on both affective response and cognitive achievement. The dissimilarities in techniques for measuring affective response and cognitive achievement necessitated the creation of an eclectic design.

Eclectic Design

Quantitative studies dominate the methodology of educational technology research. Robinson and Ong (1988) reviewed the methods employed by the authors of research journal articles from ECTJ and JID, published during the decade 1976-86, and found that only 65 of 216 studies (30%) utilized methods other than experimental or survey. Experimental methods alone accounted for 57% of all studies. Altogether, quantitative methods were used for about three out of every four studies. Still, a fourth of all studies strayed from hard line quantitative approaches, and that percentage may be growing. A dozen or more alternative methods have appeared that each have their advocates. Importantly, in the smorgasbord of now-acceptable research techniques we find approaches for the study of qualitative questions.

Like the study at hand, many - maybe most - qualitative studies also have a natural quantitative component. In a simple example, even those things that must be measured according to their value (quality) can also be counted (quantified). Even with naturalistic inquiry, which presumes that the investigator collect data without a priori assumptions, there is no theoretical exclusion of **numerical** data in the collection effort. Consequently the naturalistic study may very well rely upon statistical techniques for the ultimate analysis of some or all of the information collected. Furthermore, there is nothing to infer that the naturalistic researcher will not automatically add even an experimental episode when the evolving structure of a study points to the need for quantitative analysis to fulfill the needs of the broader inquiry. Indeed, the researcher's option to combine elements from the various classic research designs may drive the research design processes of the future.

None of this is to suggest that the authors are herein espousing circumvention of sound procedures and abandonment of reason-based good practice. To the contrary. The clear implication is that good practice demands that research designs be like good food recipes. We must call for every ingredient that is needed. Thus as the skillful cook combines the recipe for crust with the recipe for pie filling, the skillful researcher can combine the design elements for a qualitative study that is the pie shell into which s/he pours the results obtained from an investigation based upon a quantitative design. These authors believe that they have cooked up such a dish (as have many, many other researchers before them). Rather than call the design a recipe, however, the authors have chosen to refer to the interleaving of functionally different design elements as eclectic. Eclecticism has clear advantages -- it allows one to borrow the best ideas and leave out the worst, and it is bereft of any baggage that requires the practicing eclectic to be the advocate of any one of the competing philosophies. The authors are not spokespersons for the experimental method which was used extensively in the study reported here; nor are they spokespersons for quasi-experimental, quasi-naturalistic or naturalistic methods which also played a part in the study.

Design Imperatives

When the authors sat down to discuss this study two years ago, the objective seemed clear and simple. There was a monumental hole in society's knowledge base concerning the bridge between affective response and cognitive learning. The authors had collaborated on an article (Braden and Beauchamp, 1987) which had toyed with some theory about display of information along a visual-verbal continuum -- a heuristic piece inspired by Wileman's Typology (1980). An obvious limitation of the Wileman continuum was that it applied only to messages conveyed visually. Also, even the end of the spectrum that was represented by totally pictorial visual material had been studied primarily for its utility in delivering cognitive concepts. From a sensory standpoint, the earlier work had been unidimensional, dealing only with the sense of sight. Intellectually the earlier work had been unidimensional, dealing only with knowing (cognition) and paying scant attention to appreciation, emotion and feeling (affect).

The first design imperative for this study was that both of the primary learning senses (sight and hearing) be included. The second imperative was to extend the inquiry into both the the affective and cognitive domains. The third design imperative was that the final design must have holistic integrity. In that sense, complexity could not be allowed to obscure the value of individual research procedures, nor could the detail of any technique command so much attention as to overwhelm the project as a whole. In other words, everything had to complement everything else.

The fourth design imperative was that every effort would be made to prevent this study from turning into another "Medium A vs Medium B" study. The very idea that instructional delivery systems such as slide + tape programs increase learning is one not widely accepted by all authors (Clark, 1987; Simonson & Burch, 1975; Simonson, 1987). Perhaps Clark overstated the case when he said that media were "mere vehicles that deliver instruction" and insisted that "they do not influence student achievement any more than the truck that delivers groceries causes changes in nutrition" (1983. p. 445). Overstated or not, he got everybody's attention. These authors wished not to compare vehicles (slide + tapes), but rather the way that the cargo (content) was packaged (the design formats). That moved this study into the arena of media attribute research with which Clark (1987, p.10) also has misgivings. But, the historical inadequacy of cognitive research on media attributes seemed, if anything, to be one more compelling reason to pursue this cognitive/affective study.

Attending to the second of these imperatives was the most troublesome because there are not yet any traditions or standards for performing research in the affective domain. Much confusion and ambiguity surround the affective domain. Martin and Briggs (1986) wrote an oversized book on the integration of the cognitive and affective domains. Yet they too were forced to be imprecise (or to use their term, "unfocused") about the definition of the affective domain and related concepts:

> The affective domain poses a unique set of problems for educators. First the definition of the domain and the concepts that comprise it are so broad and often unfocused that all aspects of behavior not clearly cognitive or psychomotor are lumped together in a category called the affective domain. For example, all of the following terms can be found associated with affect: self-concept, motivation, interests, attitudes, beliefs, values, self-esteem, morality, ego development, feelings, needs achievement, locus of control, curiosity, independence, mental health, personal growth, group dynamics, mental imagery, and personality (p.12).

Ringness (1975) defined the affective domain and used another set of terms -- emotions, interests, preferences, tastes, attitudes, values, morals, character, and personality adjustment -- as important parts of the domain. Martin and Briggs (1986), like Gephart and Ingle (1976), identify affective behaviors as having both an emotional tone and a cognitive component. Neither set of authors has suggested a sure fire way to separate the two components or even to identify where one leaves off and the other begins. Isolating anything to do with the affective domain is, to use the vernacular, like attempting to nail jello to the wall.

The Sight and Hearing Continua

The Wileman Typology basically established a sight continuum with all words at one end and no words at the other that interleaved with a concurrent continuum that progressed from no pictorial content to totally pictorial. The operational terms which the current authors have used previously to deal with this reciprocal pair of variables are "verbal-visual" (Braden & Beauchamp, 1986).

In order to treat the range of various kinds of visual images used in instruction as a single variable it was necessary to consider the typology as a single continuum, assume some cognitive message content, and re-name the poles of the continuum as "verbal" and "non-verbal." This was more a nomenclature change than anything else. Anytime a slide is shown, for example, **something** appears on the screen. Accordingly, the inverse relationship of word elements to pictorial elements means that in this typology **both** variables are present if either variable is represented.

For the sense of hearing the analog is also a pair of reciprocal variables, but here too the variables are inversely related and can be treated as a single continuum with the bipolar extremes labeled verbal and non-verbal.

Figure 1 shows graphically how these sight and hearing continua would apply to the visual and sound components of a slide+tape program. A confounding factor for this type of investigation is the lack of complete understanding about hemispheric specialization of the human brain. The so-called left brain / right brain dichotomy may have a high correlation to the visual and audible continua as shown in Figure 1. However, this study was not intended to be brain laterality research, and the authors reserve judgment on the implications of these results to the growing body of brain function literature.

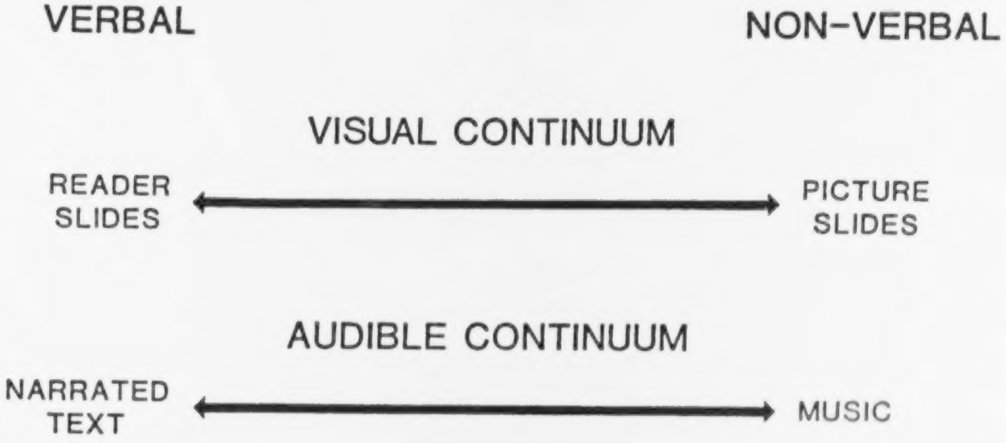

Figure 1. The visible and audible continua

METHODS

Four slide + tape presentations were constructed by the primary researcher (Beauchamp, 1988) to be shown to four different groups of students. A two-continua approach was employed, establishing a visual continuum and an audible continuum with "verbal" and "non-verbal" as the bipolar extremes on both continua. The design features of each of the four presentations are illustrated in Figure 2. They can be described as single screen, linear slide + tape presentations approximately 7 minutes 30 seconds in length consisting of the following elements: (Treatment A) picture slides as the "non-verbal" element of the "visual" continuum and narrated text as the "verbal" element of the "audible" continuum; (Treatment B) reader slides as the "verbal" element of the "visual" continuum and narrated text as the "verbal" element of the "audible" continuum; (Treatment C) reader slides as the "verbal" element of the "visual" continuum and music as the "non-verbal" element of the "audible" continuum; and (Treatment D) picture slides as the "non-verbal" element of the "visual" continuum and music as the "non-verbal" element of the "audible continuum. Data on cognitive achievement were collected through the use of a pretest, a posttest, and a post posttest designed for this study.

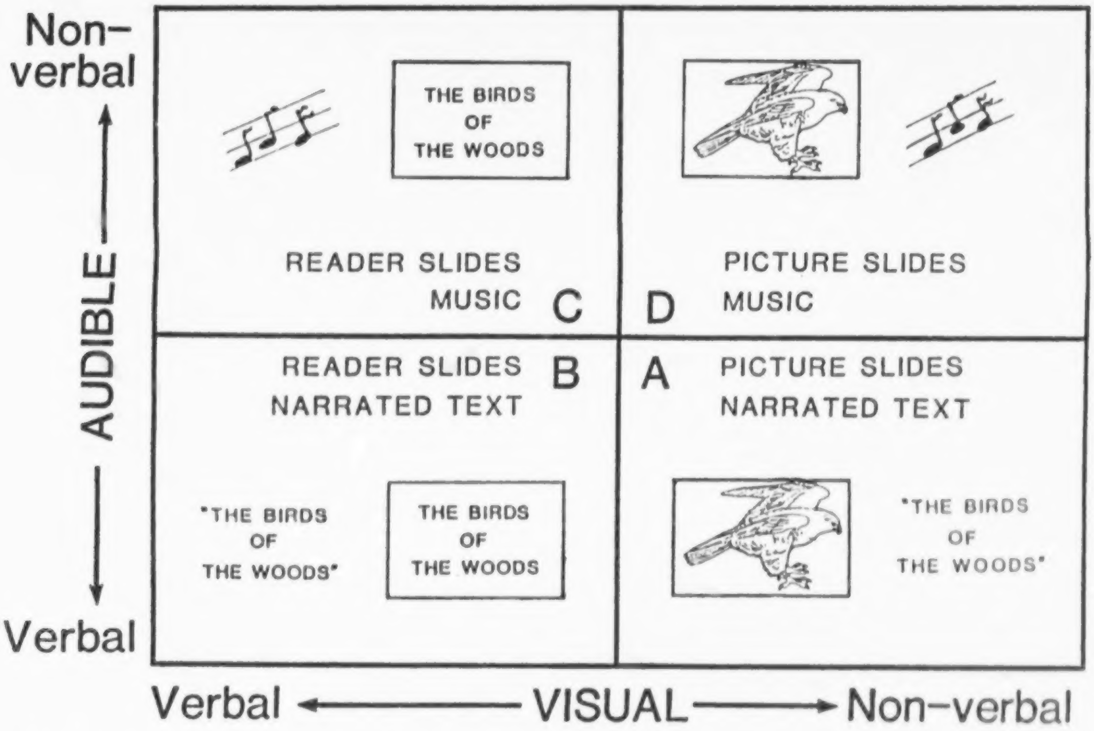
Non-verbal
AUDIBLE
Verbal
THE BIRDS OF THE WOODS
READER SLIDES
MUSIC
C
D
PICTURE SLIDES
MUSIC
READER SLIDES
NARRATED TEXT
B
A
PICTURE SLIDES
NARRATED TEXT
"THE BIRDS OF THE WOODS"
THE BIRDS OF THE WOODS
"THE BIRDS OF THE WOODS"
Verbal
VISUAL
Non-verbal

Figure 2. The slide + tape matrix

Affective reaction to the four treatments was measured as a function of attitudes toward the presentations themselves, i.e., the reaction toward "the show", and toward the topic of the presentation. (In all cases the subject matter was about the relative barrenness of the oceans -- an esoteric topic previously unencountered by all subjects.) A semantic differential technique using two concept ideas and eleven bipolar adjectives for each concept, an attitudinal questionnaire using both Likert scale questions and techniques from the Semantic Differential, and two descriptive essay questions were employed to collect data in the affective domain.

A quasi-naturalistic "retelling" procedure was used to gain additional insight into the cognitive achievement of the four treatment groups. The retellings also produced attitudinal data not obtained by the attitudinal instruments, even though that was not the original purpose for employing the procedure.

Statistical data were compiled and computer analyzed through the use of a commercial statistical package. The procedures were traditional: analysis of covariance, one-way analysis of variance, Dunnett's Test for Critical Differences, and crosstabulations. The results of the statistical procedures are reported in detail elsewhere (Beauchamp, 1988).

Findings

The findings of this study showed that significant differences existed among the four treatment groups in the degree of cognitive achievement. The evidence was clear that the ways in which viewed material and heard material are combined make a difference in learner achievement. Earlier findings suggesting that students learn more when information is seen than heard (e.g., Treichler, 1967) were confirmed. Also, earlier findings suggesting that visuals have utility as a trigger for recall of prior knowledge that can be used to help in cognition were confirmed (e.g., Fleming & Levie, 1979).

There also were significant differences among the groups in the degree of affective response. These significant difference extended to both the presentation itself and to the topic of the presentation. The evidence here too seems clear that affective response can be influenced by the design decisions which determine the formula for combining heard elements and viewed elements of instruction.

There are linkages between affect and cognition, but the nature of these relationships was not isolated by this study. Some linkages were demonstrated to be hit or miss. Among other things, affective stimuli were not shown to reliably stimulate cognitive recall.

Conclusions

The statistically significant findings together with the naturalistic data have been incorporated into the following summary set of conclusions. Although these results are presented in a generalized form and are drawn from data analysis, there is not enough evidence in this single study to claim generalizability to other environments.

1. In a slide + tape (sight + sound) presentation, when verbal language is used to appeal to only one sense via either printed or spoken words, cognitive achievement is not significantly diminished.
2. Pictures used in a slide + tape (sight + sound) presentation prompt viewer recall from memory or experience of information not in the presentation.
3. Cognitive stimuli prompt immediate cognitive recall.
4. Visuals, especially photographs, prompt immediate positive affective responses to a presentation.
5. Music from a slide + tape (sight + sound) presentation, more so than visuals, prompt long range, or delayed, positive affective responses.
6. Students are aware of "when" and "if" they are learning. Changing the delivery-of-instruction mode does not change this apparently innate sense of learning.
7. A desired change in attitude is prompted through the introduction of new concepts and ideas, not through the presentation itself.

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Title:

Factors Influencing Mental Effort: A Theoretical Overview and Review of Literature

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Factors Influencing Mental Effort:

A Theoretical Overview and Review of Literature

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Factors Influencing Mental Effort: A Theoretical Overview and Review of Literature

Several researchers (Krendl & Watkins, 1983; Salomon, 1984; Salomon & Leigh, 1984) have suggested that the learner's preconceptions of a medium are an influential factor in achievement. For example, Salomon found that learners perceive television as easier than print and they report investing more mental effort and learn more from a text-based lesson. Winn (1985), Hannafin (1985) and Clark (1983) have recently called for an investigation of the ways in which different forms of media are perceived and how these perceptions influence mental processing.

The purpose of this paper is to summarize the theoretical basis of the relationship between preconceptions and the construct of "mental effort", to identify factors that researchers have shown to influence mental effort and to suggest an agenda for future research in this area. General areas relevant to an examination of mental effort include 1) cognitive processing theory, 2) motivation theory, and 3) specific research on mental effort. Particular emphasis will be placed on studies that investigate the processing of video-based instruction.

Theoretical Basis of the Relationship between Preconceptions and Mental Effort

Salomon (1983a) defines the construct of "mental effort" as the "number of non-automatic elaborations applied to a unit of material" (p.42) and uses the construct to refer to the motivational and cognitive aspects of information processing. The conscious, effortful processing that results from increased mental effort is assumed to make more contact with the learner's mental schemata, leaving more memory traces and facilitating the retention of the material. An examination of cognitive and motivational theory may suggest ways that learners' preconceptions are related to the mental effort expended when processing a mediated lesson.

Cognitive Theories

Several theories have been offered to explain the cognitive processing of video-based materials. One set of theories present the viewer as passively involved in the viewing experience. Proponents believe that the degree to which a person attends to the video effects the level of comprehension (Singer, 1980). In contrast, proponents of various active processing theories contend that attention results from the need to fill slots in schemata with expected information (Anderson & Lorch, 1983).

Reactive theory. In the reactive theory of television viewing, television is seen as eliciting and sustaining attention through salient formal features such as quick movement, quick cuts, and sound (Anderson & Lorch, 1983; Singer, 1980). Singer (1980) further developed this theory and proposed that, due to constant visual and auditory changes, television creates a continuous series of orienting responses. According to Singer, a heightened awareness, or orienting response, occurs whenever a person is presented with any new or unexpected stimulation; once the new information can be assimilated into a preestablished schema, a person quickly habituates to the situation in order to be ready to respond to other new stimuli in the environment. Singer attributed television's appeal to the viewers' inability to habituate to the televised stimuli and the resulting pleasure that is derived from small doses of novelty. With the constant appearance and reappearance of characters on television, the viewer must continually attempt to orient to the information presented and therefore continues to attend to the program even if no longer interested.

The viewer is influenced by the video program and, as such, the viewer's [illegible] intentions, and strategies are perceived as exerting a minimum of influence. Comprehension is seen as following from attention, and in fact, the information retained is considered to be at a low level since "pressures of attention to novel stimulation can actually interfere with our ability to store" information (p. 38). He concluded that television viewing as a passive cognitive activity "will yield considerable recognition memory without efficient retrieval" (p. 42).

Active processing theories. This view is in marked contrast to the active processing theories (Anderson & Lorch, 1983). Active processing theorists contend that viewers are instead extremely well "habituated" to television viewing, and that habituation, or well established scripts, may inhibit the active processing of video-based instruction. Theorists assume that viewers develop expectations about the temporal and conceptual flow of television programs through experience. These expectations are part of a viewing schema that guides the viewer in comprehending the video program.

Active processing theorists propose that attention is maintained by the viewer's ability to answer questions posed by the schema. If all the "slots" dictated by the schema are filled, attention is terminated, or if the user is unable to call upon an appropriate narrative schema, attention is also terminated. (Anderson & Lorch, 1983). Whereas with the reactive theory, comprehension follows from attention, from an active processing viewpoint, the primary casual relationship is from comprehension to attention. The viewers' need to fill slots in their schemata guides their attention.

This notion of schema is similar to the concept of "scripts" promoted by Shank and Ableson (1977). Like schemata, scripts are made up of slots and requirements about what can fill these slots. But whereas schemata are broad organizational structures that include both concrete and abstract knowledge, a script is a type of schema that contains an individual's knowledge of an event sequence (Ableson, 1981). When an individual is presented with a situation with which he or she has previous experience, the individual then enacts a script that was written when the experience was new.

As an event-based cognitive structure, scripts play a double role in television viewing (Ableson, 1981). One type of script is used for the understanding of the events seen on television and another type of script is used in the behavior of television viewing. A script-based understanding of the events involves the "cognitive retrieval of previous situations to which the present situation is similar" (Ableson, 1981, p. 719) and typically utilizes a type of script that Shank and Ableson (1977) refer to as a situational script. For example, when one scene in a television program presents the hero in his living room and the next scene shows him at a crime scene, most viewers do not assume that the crime scene and the living room are in the same location. The viewers' situational scripts provide the connecting events which may lead them to conclude that the hero left his living room and drove to the scene of the crime. Such situational scripts are critical to the comprehension of events that are viewed on television.

But as a behavior, television watching involves an instrumental script rather than a situational script. Instrumental scripts are similar to situational scripts but instrumental scripts involve only one player, whereas situational scripts involve multiple participants (Schank and Ableson, 1977). Although there may be several people present when an individual is watching television, the behavior of watching television is a personal act that requires only one participant. Instrumental scripts also differ from situational scripts in that the sequence of actions in an instrumental script is so fixed and uninteresting that the steps in the process may be forgotten entirely and all that is usually remembered is the goal. For example, if you were to ask learners what they do when they watch

TV, you would probably be told that they just "turn it on and watch". Because we can assume that most learners have had extensive prior experience with watching television, we can assume that learners have well developed instrumental scripts for such activities, however, the specific situational script engaged by the learner would depend on the learner's experience with the events depicted in the television program.

Langer and her associates (Langer, Blank, & Chanowitz, 1978, Langer & Imber, 1979) use the concept of mindlessness, rather than scripts, to explain habitual information processing in the face of familiar stimuli. In order to be processed mindlessly, a task or message must be overlearned and congruent with an individual's past experience. When the message appears to be familiar and fits in well with the individual's anticipatory schema, a routine for the activity substitutes for active processing and information perceived to be known is ignored.

The lack of conscious control over the performance of a task that is inherent in mindless behavior leaves the individual vulnerable to problems or errors in behavior. Based on Langer's theory, it seems likely that learners who are accustomed to television viewing as a recreational task would have difficulty modifying their performance in response to an instructional videotape.

Mindlessness, scripts, and schemata are all theoretical constructs that place a great deal of emphasis on the role of prior experience. The more familiar individuals are with a task, the stronger their preconceptions of it. The stronger these proconceptions, or the more easily they are available to processing, the greater the probability that these preconceptions will guide the individual's response to the presented material. The extent to which preconceptions include beliefs or expectations about the amount of mental effort required by the task may affect the amount and nature of non-automatic elaborations of the material (Salomon, 1983b).

Motivational Theories

Salomon's (1981) concept of "amount of invested mental effort" (AIME) "is cognitive in the sense that it pertains to mental elaborations of information material. But as these elaborations are controlled, rather than automatic, their employment implies an measure of choice" (Salomon, 1983, p. 44). Because the individual must choose to engage in active processing, the construct of mental effort has motivational, as well as cognitive, components.

A cognitive view of motivation emphasizes the internal events that lead an individual to engage in an activity. These internal events may include curiosity, uncertainty, causal attributions, and expectations for success (E. Gagne, 1985). Berlyne's (1960) curiosity theory and Weiner's (1979) attribution theory seem especially applicable to the processing of a mediated lesson.

Curiosity theory. Although not directly concerned with the construct of mental effort, another cognitive theory of motivation may help to explain the increase in achievement, and presumably mental effort, that is so often found when content is presented in a novel manner. According to Berlyne (1960), when the learner experiences something that is novel, surprising, or complex, a heightened sense of arousal and uncertainty is produced. This aroused state leads to exploratory behavior in order to reduce the unpleasant feeling of uncertainty. As the learner gathers information, the uncertainty is reduced and the resulting reduction in arousal is reinforcing to the learner. Berlyne's theory may account for the increases in attention in response to televised excitement documented by the reactive theorist of television processing (Singer, 1980).

In addition to the perceptual curiosity that results from novel, surprising or complex stimuli addressed above, Berlyne (1960) also recognizes epistemic curiosity caused by thoughts, beliefs or attitudes that may be discrepant with prior beliefs.

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Epistemic curiosity may be especially valuable, as questioning strategies may be utilized to create the cognitive conflict that results in increased exploratory behavior directed toward the reduction of uncertainty. In general, Berlyne's theory suggests that novel situations or cognitive conflict may result in a temporary increase in mental effort directed at reducing the uncertainty that is experienced when learners confront a stimulus that is inconsistent with their prior experience.

Attribution theory. There is some research evidence that learners attribute their success and failure in learning from print to different causes than they attribute their success or failure in learning from television (Salomon, 1984). According to Weiner (1979), the reasons that people give for a success or failure contributes to the mental effort that will be exerted in similar situations in the future. Weiner proposed that individuals attribute their success or failure to one of the four broad classes of luck, effort, difficulty of the task, or ability. The attribution provided in a situation of success or failure influences the extent to which the individual will persist at the task. Weiner contends that casual attributions for failure to unstable causes such as effort or luck increase task persistence more than attributions to stable causes such as ability or task difficulty. Of the two attributions that increase task persistence, attributing a task outcome to effort results in the greatest task persistence since effort is under the control of the individual.

The perceived task difficulty is also thought to influence the amount of effort expended (Weiner, 1979). Although task difficulty is a stable cause beyond the control of the individual, it is instrumental in providing cues as to the efficiency of effort. Weiner contended that individuals seek to engage in tasks in order to gain information about their ability. Individuals seem to work best at tasks of intermediate difficulty because engaging in difficult tasks provides little information about their ability or effort expenditures and may be perceived as a waste of energy while easy tasks are perceived as unnecessary for success. When faced with tasks of intermediate difficulty, individuals that attribute success or failure to effort exert a maximum of effort since these individuals believe that the best performance strategy for high achievement in such situations is to try harder.

Salomon (1984) analyzed student attributions of success and failure in learning from print and television and found that students attributed success with television to external causes such as ease of material, and attributed success with print to the reader. Conversely, failure with television was attributed to internal causes such as lack of effort and failure with print was attributed to the difficulty of the material. It is interesting to note that learners attributed success and failure with print to stable causes, but they attributed failure with television to the unstable attribution of effort. As previously stated, Weiner (1985) has suggested that attributions of effort can result in the greatest task persistence since it is very much under the control of the learner. This study suggests that if learners can come to view television as worthy of the exertion of additional mental effort, or moderately difficult according to Weiner, then they will exert a maximum of effort.

Summary of cognitive and motivational theory

A review of cognitive and motivational theory indicates that conscious and unconscious preconceptions such as scripts, schemata, attributions, and curiosity each seem to influence mental effort. According to cognitive and motivational theory, learner preconceptions are influenced by several factors.

Past experiences. Past experiences play a crucial role in the preconceptions that learners' bring to a learning environment. Learner scripts and schemata are abstracted from prior experience and extensive prior experience may result in overlearning and mindless behavior.

Perceived task. The particular script or schema engaged in response to a learning task is influenced by the perceived purpose of the task. Attribution theory also indicates that the way that the task is perceived influences the amount of mental effort engaged in processing a lesson.

Characteristics of the media. The characteristics of the media cue the learner as to the appropriate instrumental script to engage and contribute to the preconceptions that learners bring to an instructional setting. In addition, curiosity theory suggests that novelty and structural characteristics such as embedded questions may create cognitive conflict and result in a temporary increase in mental effort in order to reduce the internal conflict.

In summary, the learners' past experience, the perceived task, and the characteristics of the media may each contribute to the preconceptions that learners' bring to an instructional setting, which may in turn, influence the invested mental effort. Research that has examined some of these factors will be reviewed next.

Research on Preconceptions and Mental Effort

Salomon and Leigh's (1984) finding that high ability students perceived television to require less effort than low-ability students and performed poorer than low -ability students lends credence to the idea that preconceptions of the effort required to process a lesson influence achievement. In order to more closely examine the influence of preconceptions on mental effort, this section will 1) present the results of studies that surveyed learners' preconceptions of several forms of media, 2) examine the type of learning that is influenced by increased mental effort, then 3) examine studies that have manipulated the perceived task and the characteristics of the media to determine the effects on mental effort.

Learner Preconceptions

Since preconceptions of a medium have been shown to influence the mental effort investing the processing of a lesson, the way in which different media are perceived is of interest to an examination of the influence of preconceptions on mental effort. As reported earlier, Salomon found that learners' perceive television as easier than print (1983b,1984) and report expending less effort in learning from televised lessons than from print based lessons (1983b; Salomon & Leigh, 1984). These findings may result from the fact that most experience with reading has been for educational reasons and most experience with television has been for entertainment and that learners' instrumental scripts would reflect these prior experiences.

Krendl (1986) further examined students' preconceptions of print and television and expanded her examination to include computers and writing. Krendl found that students preferred computers to television, television to reading, and reading to writing. They felt that television was the least difficult, followed by, in order of preference, reading, writing and computers. They felt that they would learn more from reading, followed closely by computers. Writing was placed further down the scale, followed by television

Krendl notes that, in general, the more an activity is preferred, the less difficult it is perceived to be, and the less likely one is to think one will learn from it. Although her general conclusions were consistent with Salomon's work, students' preconceptions of writing and computers often contrasted with this general conclusion. Students rated writing as one of the more difficult activities, yet they rated it as low on the learning scale. Learners' preconceptions of computers also contrast with Salomon's findings that students tended to prefer media that were easier, but were consistent with his observation that students felt they would learn more from a presentation that they believed to be difficult.

It appears that writing and computers differ from reading and television in important ways. Writing differs from television and reading in that writing involves the generation, rather than the encoding, of concepts and ideas. Like writing, computer use may also involve the active generation of concepts and ideas rather than the passive reception of information that is typical of reading and watching television. Even when computer use involves the encoding of ideas, as in computer-assisted instruction, it may still be difficult for learners to rate computer use along the same continuum as reading and television watching because computer-assisted instruction is a relatively new instructional strategy and students may have less predictable scripts for computer use.

Mental Effort and Learning

Some researchers (Krendl & Watkins, 1983; Salomon, 1983b; Salomon, 1984; Salomon & Leigh, 1984) seem to suggest that increased mental effort does not affect factual recall, but instead results in greater inferences. These findings indicate that attention may be sufficient for recall but not for higher level cognitive processing, which is consistent with reactive theories of television processing.

In addition to the evidence for an increased number of elaborations as a result of the increased mental effort exerted in text-based instruction, there is some evidence that the elaborations are of a different quality. Whereas children exposed to a video story base their inferences on visual information, students that had heard the story read aloud showed more evidence of inferences based on general knowledge and personal experiences (Meringoff, 1980).

According to schema theory, learners create narrative schemata from past experiences. Salomon (1983b) presented learners with a jumbled version of a videotape and found that although the learners that received a jumbled version of the tape reported more mental effort than learners that received a normal version of the program, the learners that received the jumbled version had lower achievement scores. Although Salomon (1983b) suggests that simply expending more effort does not guarantee increased inferences when learners are unable to fit the information into a preexisting schemata, when Krendl and Watkins (1983) conducted a similar study but kept the original narrative intact and added irrelevant segments, the learners attempted to fit the incongruent information into the story line. In the Krendl and Watkins study (1983), the availability of a main intact narrative apparently provided the structure necessary to tap into the viewer's narrative schemata. In Salomon's study, self reports of increased mental effort indicated that the learners did attempt to elaborate on the material, but, consistent with schema theory, their lower performance suggests that they may have abandoned the effort due to an inability to fit information into an existing schema.

The Influence of Perceived Task on Mental Effort

Several studies (Krendl & Watkins, 1983; Ksobiech, 1976; Salomon & Leigh, 1984) have attempted to manipulate students' perceptions of the task purpose in order to increase the amount of invested mental effort. The results of these studies show that students that are instructed to learn from a lesson exhibit more mental effort (Salomon & Leigh, 1984) and exhibit greater achievement (Krendl & Watkins, 1983; Salomon & Leigh, 1984) than students that are instructed to attend to a lesson for fun. In addition, it appears that the perceived purpose of the task also influences the modality (audio or video) that receives the primary attention when viewing a video tape (Ksobiech, 1976). For example, when instructed to pass an exam, subjects frequently sought information from the auditory channel. Since learners are very familiar with receiving the content on which they are to be tested through auditory channels, as in a classroom lecture, their increased attention to the auditory channel may reflect such scripts.

The Influence of Characteristics of the Media on Mental Effort

The characteristics of the media have been suggested as an influential factor in the amount of mental effort invested in a learning task and one of the primary differences between text and televised instruction lies in the ability of the learner to control the pace, therefore, these differences may be offered as an alternative hypothesis to explain the increase in both number and kind of elaborations evidenced by students that received a print lesson. This alternative hypothesis was tested by Krendl and Watkins (1983). However, Krendl and Watkins found that students that were allowed to stop a videotape at any time they wished to ask a question, make a comment, and so forth, did not exhibit significantly higher scores on measures of recall and higher level processing than students that were not allowed to control the pace of the videotape, suggesting that student control of the pace of a video lesson does not significantly increase the amount of mental effort invested in processing a video-based lesson.

Summary

Preconceptions based on past experiences, perceived task utility, and media characteristics each seem to influence mental effort. Past experiences influence the scripts and schemata that individuals bring to the learning environment. While of crucial importance, past experiences can not be easily altered by the researcher, teacher or instructional designer. However, learner expectations of the future usefulness of the information can be successfully manipulated. Researchers (Krendl & Watkins, 1983; Salomon & Leigh, 1984) indicate that students that are instructed to learn from a lesson exhibit significantly greater mental effort and achievement than individuals instructed to attend to a lesson for fun. In addition to manipulating the learner's perception of the goal of the task, the characteristics of the media may also be manipulated to increase the amount of invested mental effort. Although learner control of the pace of a video lesson did not seem to significantly increase achievement (Krendl & Watkins, 1983), there are other structural characteristics of video-based instruction that may be varied in order to increase mental effort.

Suggestions for Future Research

Several researchers (Britton, Glynn, Meyer, & Penland,1982; Burton, Niles, and Lalik,1986; Reynolds and Anderson, 1982; and others) have manipulated the structural characteristics of text materials and used a secondary task techniques to measure the amount of cognitive capacity used during processing the printed lessons. In these studies, subjects were told that comprehending the text was their primary task, but were also told to depress a key as quickly as possible following a given sound. This technique assumes that individuals have a fixed amount of cognitive capacity. When subjects are concentrating on the primary task of attending to the lesson, it is assumed that subjects will take longer to respond to the sound than in a baseline condition because there would be little cognitive capacity available to process the secondary task and, therefore, reaction time would be delayed until additional capacity became available. This technique also assumes that there is a correlation between response time to a secondary task and the amount of mental effort, or cognitive capacity, in use at the time of the response.

It is interesting to note that in these studies, "cognitive capacity usage" has been operationally defined in a manner that is similar to Salomon's construct of mental effort. Although this technique has not been used in studies of mental effort, Salomon (1984) has suggested that one way of measuring "amount of invested mental effort" (AIME) is by the delay time in responding to some secondary task while attending to the primary task of reading or viewing the stimulus material. Since cognitive capacity usage and AIME are operationally define in a similar manner in these studies, we can assume that the techniques that are shown to increase the amount of cognitive capacity used in processing would also increase AIME and achievement. An examination of studies that incorporate a secondary task technique to measure the amount of mental effort invested in a learning task may suggest ways that the structural characteristics of video-based instruction can be modified to increase the mental effort that learners invest in processing the lesson.

Embedded question

Several studies (Britton, Piha, Davis & Wehausen, 1978; Reynolds and Anderson,1982; and others) examined the role of embedded post-questions in text using a secondary task technique to measure the amount of cognitive capacity used during processing and may be of interest.

Reynolds and Anderson (1982) found that reaction times to a secondary task were significantly delayed when subjects were reading text segments containing information that was relevant to the questions as compared to segments containing question-irrelevant information. Britton and his colleagues (Britton, Piha, Davis & Wehausen, 1978) conducted a similar study using text-relevant questions, irrelevant question or no questions. They found than the cognitive capacity usage increased when questions that were relevant to the text content began but similar increases were not observed when irrelevant questions began or when no questions were provided. This study suggests that the increased cognitive capacity usage that results from embedded questions is due to some sort of content specific processing rather than an effect of the presence of embedded questions in text. Because the increase in reaction time to a secondary task was largest on pages immediately following the questions, Britton and his colleagues concluded that the increased cognitive capacity usage following the embedded questions indicates that the learners are engaging in elaborations of the content materials.

Although these studies did not examine cognitive capacity usage in response to embedded questions in video-based materials, Anderson and Biddle (1979) thoroughly reviewed the literature on embedded questions in studies that used film, lecture, videotape or text and found that the medium of presentation did not seem to matter much; questioning statagies affect the processing of text and video-based instruction similarly.

Several researchers have included embedded questions in video-based materials and measured the affects on achievement with mixed results. Some researchers (Heestand, 1980; Lipsky, 1983) have found that the inclusion of embedded questions yields greater achievement scores than the presentation of a video tape without embedded questions, while other researchers (Schaffer & Hannafin, 1985; Teather & Marchant, 1974) suggest that the embedded questions must be followed by feedback in order to effectively increase achievement. Dalton (1986) suggests that requiring learners to actively respond to the embedded questions is even more effective than simply providing the learners with embedded questions and feedback. If learners do invest greater cognitive capacity in processing a lesson that includes embedded questions, increased in mental effort may account for the increases in achievement documented in these studies.

In future research, the incorporation of a secondary task technique as a dependent measure would allow researchers to determine if techniques, such as embedded questions, that have been shown to increase the cognitive capacity used in processing text-based materials would also increase the mental effort invested in processing video-based lessons. Future research in video-based instruction should also explore the manipulation of other structural characteristics to determine ways that the learners' preconceptions of television as a passive medium can be overcome to result in increased mental effort and achievement.

Other factors

In addition to the use of embedded questions, several other methods of increasing the cognitive capacity used in processing a text-based lesson have been investigated. A few of the techniques that would be appropriate for use with video-based instruction are briefly noted below.

INFORMING THE LEARNER OF THE OBJECTIVES: Students that were provided with specific learning objectives used more cognitive capacity when reading objective relative information than learners that were provided with general instructions to pay special attention to a particular section or learners that were provided with no learning objectives (Britton, Glynn, Muth, & Penland, 1985).

RELATING TO PRIOR KNOWLEDGE: Several studies (Britton, Holdredge, Curry & Westbrook, 1979; Britton & Tesser, 1982; and others) suggest that learners invest more mental effort in processing lessons in which they have some prior knowledge of the topic. For example, when learners were presented with a passage that was meaningless without a title, the learners that read the passage with the title invested more mental effort in processing the passage than the learners that received the same passage without the title (Britton, Holdredge, Curry and Westbrook, 1979). It appears that the title may have made it possible for the learners to activate prior knowledge of the topic, and therefore, to engage in active elaboration of the content of the passage.

NARRATIVE VS. EXPOSITORY: Learners also seem to invest more cognitive capacity in processing narrative text than expository text (Britton, Graesser, Glynn, Hamilton, & Penland, 1983). Britton and his colleagues hypothesized that learners may be more familiar with narrative prose and, therefore, have better established schemata for narrative prose than for expository prose. The presence of well established schemata would allow the learners to elaborate on the content in more detail. The elaboration process would fill the learners cognitive capacity more completely and would potentially result in an increased number of inferences based on the content.

LEARNER EXPECTATIONS OF IMMEDIATE VS. DELAYED TEST: Britton (1980) found that students that expected a delayed test invested greater effort in processing the lesson than students that expected an immediate test. It is interesting to note that recall scores were similar for both groups, however, as previously stated, achievement gains from increased mental effort may not be evident on a test of recall.

Conclusion

This paper has attempted to review the current literature on preconceptions of media and on the relationship of learner preconceptions to the amount of mental effort invested in a learning task. It has been suggested that methods that increase the cognitive capacity used in processing text based lessons be investigated to determine their potential for overcoming learners' preconceptions of television as a passive medium requiring little mental effort.

Additional research that examines the relationship of leaner preconceptions of "newer" media (such as computers) to the amount of mental effort invested in the learning task may also be of value. Krendl (1986) has suggested that learner preconceptions of computers do not follow the pattern suggested by Salomon in his investigation of learner preconceptions of print and television, indicating that further research is needed in this area. It is possible that learner preconceptions of "new" media may change as the learners engage in the process of becoming familiar with the media.

It is hoped that further research on the issues identified in this paper will provide valuable information that will have practical applications for the design of more effective video-based instruction.

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Educational Technology: Integration?

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Educational Technology: Integration?

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Overview

This article will present a perspective of the current state of technology-assisted instruction integrating computer language, artificial intelligence (AI)) and a review of cognitive science applied to instruction.

In the past decade the availability of the microcomputer in educational technology has increased at a phenomenal rate. Today almost every student in the United States has access to a microcomputer. Routinely, instruction is included in the curriculum on computer literacy and higher level languages such as BASIC, LOGO, PASCAL and C. The age of the microcomputer and enhanced educational technology has arrived. At least, the technology has arrived; unfortunately the hardware appears to lead the market, while use of the technology for improving learning lags far behind. Courses on computer literacy, languages, and the relatively few good educational software programs are beneficial, however, these courses do not meet the tremendous potential that educational technology offers in assisting educators and researchers in the quest to improve learning.

The need for basic research using this technology along with its essential attributes is of paramount importance if the situation described above is to be improved substantially. No longer are educators, students and parents going to be elated with fancy graphics, a barrage of games, and relatively useless computer programs that do little more than a workbook. The goal of the use of the microcomputer and technology should be one of improving learning based on sound educational theory.

The Language of Instructional Technology

A programming language (to include authoring systems) has at least three goals: 1) it is a design tool; 2) it is a vehicle for human communication; and 3) it is a vehicle for instructing a computer.

In the first of these goals, the programmer or designer must determine an overall strategy that will accomplish the instructional objectives. The designer must choose a structure that will be correct, efficient, and amenable. For practical reasons, the design is restricted by hardware (memory, processor, secondary storage, and language). When the process of design becomes more defined, the computer language becomes more important. The language shapes the way in which the designer thinks about problems, as does the computer language chosen. Programming languages serves as a communication medium between designer and program. First a designer must delineate what the intended instructional program is to do. Too often the language will make the designer/programmer concentrate on the "how" instead of the "what". The ability to understand this paradox is crucial. The question is should every conceivable useful construct be contained in the language or should the language contain the constructs that are just right for the program/problem at hand? This decision should be based on the competency of the designer and the purpose of the instructional program. The computer must be given the instructions if the program is to run with reasonable space, time and efficiency. The above would seem to be an relatively easy problem to deal with. The reality is that what is reasonable in a language is not always efficient. Difficult and unexpected efficiency problems typically arise not from a single language feature, but rather from a combination, an interaction of several features, in which each feature seemed reasonable by itself. Choosing the proper balance between features is what has often turned out to be more difficult than expected. Software. Basically the requirements of software can be thought of in four areas: degrees of software complexity, degree of software structuredness, degree of software requirements, and degree of software reliability.

Technology Assisted Instruction using Artificial Intelligence

The formal study of AI in computer science can be trace to the early 1960s (Feigenbaum & Feldman, 1963). The focus was on the design of computer programs that would enhance decision making, as well as storing and retrieving information. Early attempts in cognitive science to simulate the brain with computer models stimulated interest in how to simulate decision making by experts (Amarel, 1969). The application of AI in education came through cognitive science research on problem solving (Tennyson, 1982); For the last decade, artificial intelligence has generated strong interest and enthusiasm in industry and universities; it has become an important component for research and development in high-technology fields. The phrase "Artificial Intelligence" seems randomly applied in a wide variety of contexts by a growing number of people from diverse backgrounds. At issue is the nature itself of what is called intelligent,let alone whether a machine can be intelligent (Schank,1980),(Whaland, 1981),(Weizenbaum, 1977) ,(Green, 1984). A question arises of whether rules and maxims of a general nature exist and whether they are applicable across domains (Goldstein, 1975), (Simon, 1969), (Glasser, 1984). Other issues related are the questions of can a machine emulate human intelligence, or is human intelligence emulation necessary (Hayes-Roth, 1977)? The public perception has focused on the "artificial".

Computers (machines) are performing feats that we never dreamed of. The computer science community is constantly expanding the usefulness and power of their machines. This fact is important in science and engineering, but not in AI.

Most good AI programs aren't terribly useful, and many useful, "smart": programs aren't AI at all. If this distinction were understood, we could avoid a lot of confusion and disappointment (Schank, 1980).

Artificial Intelligence Principles Applied to Instruction

AI systems can take many forms, but essentially they arrange various components of an instructional system by using AI principles and techniques in a way which allows both the student and the program flexibility. However, in most applications AI systems act on the basis of preentered questions, anticipated answers, prespecified branches, and to some extent on the structure of domain knowledge and the student's representation of the knowledge (Feigenbaum, 1977), (Brown, 1977).

Natural language has become an important feature of many AI systems, thus, allowing the student to generate questions and corresponding answers through a natural dialogues with the system. (Carbonell, 1970), (Waldrop, 1984), (Rosenberg, 1977). The goal then of AI systems is to improve decision making, improve learning, while increasing the accumulation of knowledge with experience (Nelison, 1971),(Tennyson, 1984). How this goal is reach and by what method, and how effectively the system operates becomes the essential question in evaluating AI systems. The operational functions of an AI system can be determined by three main components: The content (or information to be learned, the instructional strategy, and a mechanism for understanding the student's current knowledge state. These components are referred to as the expertise module, the student-model module, and the tutoring module (Clancey, Barnett & Cohen, 1982). Ideally, an expertise module should have its own problem-solving expertise as well as static knowledge of the subject matter; a student-model should have its own diagnostic capabilities, and the tutoring module should be able to provide intelligent learning guidance with its own explanatory capabilities (Tennyson & Park, in press). Early AI system mainly focused on representation of the domain knowledge. Since the mid-1970s, however, modeling the students' learning behavior and tutorial strategies for presenting the materials have been some of the main issues in the development of AI systems (Sleeman & Brown, 1982).

Cognitive Science Paradigm Applied to Instruction

Given the memory and calculation capabilities of computers, it is possible to consider Computer Based Instructional (CBI) systems that exhibit elements of machine intelligence (that is, the ability to use new information to update files and refine the decision-making) in contrast to conventional CBI systems which offer only "dumb" management systems (for example, branching or looping programs that only consider at-the-moment information). Intelligent Computer Based Instruction can be characterized as follows: (a) provides an initial diagnostic assessment of each learner in reference to a given learning task, followed directly by a prescriptive instructional treatment; (b) gives a continuous, on-task assessment that iteratively updates the diagnosis and prescription; (c) determines the amount of instruction based on learner progress toward mastery of the learning objectives; (d) selects the sequence of instruction by a response-sensitive strategy according to cognitive processing needs; (e) adjusts the moment-to-moment instructional time so as to reduce off-task learning time, thereby improving the on-task learning time ratio; and (f) provides continuous advisement to the learner on learning progress and learning need(s).

Initial work on the MAIS began in reference to designing an adaptive instructional strategy for concept-learning (Tennyson, 1975). The combined work on adaptive variables and concept-learning has evolved into two major lines of inquiry -- both independent but highly supportive of the other. As investigations of the phenomena of concept-learning and rule-learning progressed, the sophistication of the MAIS has increased along with the understanding of human factors interacting with computer technology. The concept-learning theory followed in the empirical testing of the MAIS is a two-stage process of prototype formation and classification skill development (see Tennyson & Cocchiarella, in press). Concept-learning is fundamental to the acquisition of knowledge and the development of problem-solving skills; thus it is highly important that learners successfully acquire conceptual information in as effective a manner as possible (Shumway, White, Wilson, & Brombacher, 1983). From the beginning of the research, it was recognized that attributes of the computer had the potential for handling the instructional variables necessary for concept teaching while meeting the goal of attending to individual differences. This adaptive instructional system is formed from the interaction of learning theory, structure of information, and attributes of the computer-based delivery system.

The main variables of the MAIS are six conditions of instruction: a) amount of instruction, b) sequence of instruction, c) display time interval, d) advisement, e) embedded refreshment and remediation, and f) format of information (examples). The above conditions of instruction represent the means by which the MAIS interacts with learning theory, information structure, and delivery systems. The philosophy of the MAIS follows a cognitive psychology theory of learning that applies specifically to the memory processes of information storage and retrieval. Briefly, the cognitive learning theory of the MAIS holds that knowledge acquisition is best accomplished through experience -- both of an expository (statement) form and interogatory (question) form; also, that using knowledge for problem-solving and creative thinking requires practice. Furthermore, learning is viewed as a range of cognitive processing proceeding from the acquisition conceptual knowledge and skills to, finally, acquisition of the ability to generate new knowledge (productive thinking).

Formally designed and controlled instructional systems seem to offer the best means for facilitating learning during the initial and transition stages, while less formal systems offer more suitable means for the higher levels of productive thinking. In operation, the MAIS focuses on the transition area of learning (especially, the learning of concepts and rules), although the intention is that the MAIS offers a more efficient means for the initial acquisition of knowledge. Because learning at the highest level of cognition is not the acquisition of new, external knowledge but the use of existing knowledge in productive thinking, other less structured instructional experiences seem to be more appropriate (for example, computer-based simulations). The remainder of this section will define the theoretical basis of the MAIS according to each of the conditions of instruction.

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Screen Layout Design: Research in the Overall Appearance of the Screen

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Screen Layout Design: Research into the Overall Appearance of the Screen

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Abstract: Research into the visual effects of screen designs has been slow in developing. The paper examines the current state of that research and suggests some avenues for future efforts. The basic theme is that changes in screen designs are small, though significant factors in the design of lessons. As small factors, it is unrealistic to expect major learning gains, instead researchers should look for small changes in learner behaviors or processes.

Introduction

Imagine David, with a sling, against Goliath. Imagine David standing over Goliath. Now, imagine David, without a sling, against Goliath. Imagine Goliath standing on David.

David, an unknown youth, was able to knock-off Goliath and, as a result, continue to grow and to make an impact on his era. But, without the proper tool, i.e., a sling, the outcome could have been much different. It's not that David wasn't any good or that he didn't have anything to offer, it's just that without the sling, David wouldn't have had a chance to become king, to lead, to grow, or to change things. However, truth or legend be told, David had a major tool and as a result made a major impact.

More recently, there came about the development of an instructional technology called "programmed instruction." Research into this technology led to findings that had major impacts on the way instruction is designed. Generally, one of the most important ideas to come out of the development of programmed instruction was "planning" — the application of learner and task analyses and behavioral objectives was a significant change in the way instruction had been developed. By significant, I mean an impact that could be measured in terms of gains in post-test performance.

It seems logical and obvious to assume that a significant intervention leads to a significant result. Hit a nail with a hammer with full strength and you expect to see a gross adjustment in its height. On the other hand, molecular interventions lead to molecular changes. Hit a nail with a pair of pliers instead of a hammer and you expect to see only a minor adjustment in height. Yet, in the world of instructional technology, this same logic is not as obvious as in the world of physics. In instructional technology, when we conduct an experiment which, in effect, is designed to produce only a minor change, we act surprised when the results are not "major league."

Return to David and Goliath. Imagine David as he approaches Goliath with a stone, but no sling. When we imagine David with a sling we "expect" David to succeed (we've been conditioned by the legend). But, when we think about David without the sling, our expectations are reduced and a large element of doubt enters the picture. Maybe David can get in a lucky throw. Maybe David can do some damage and get out before he's damaged. The point is, we reduce our expectations of results when the intervention loses strength.

In educational research, we often have great expectations for minor, though not unimportant, interventions. For whatever reasons (publication demands, ego, or lack of creativity), when we attempt educational research we try all kinds of small, controllable interventions but cling to molar effects on learning as our expectation, or measure of change. The area of screen layout design is a case in point.

Limitation: The Visual Impact of Screens

Screen layout design refers to the arrangement of design elements on a screen. These elements are numerous, as shown in Tables 1 and 2. This paper is limited to a discussion of these elements as used in layout. ***Layout*** is a publication design term used to refer to the planned, visual arrangement of text elements on a page or screen. The elements listed in Tables 1 and 2 fall into two general classifications: technical elements and comprehensibility elements.

Technical Elements

Technical screen design elements are those things that engineers work with and that users have little or no control over. They are factors that are built into the equipment or factors that can be controlled by lighting, or contrast and brightness controls.

A great deal of research has been performed investigating the human factors effects of the technical elements of a display. A discussion of this research is beyond the scope of this paper because the display, as constructed, is what we (instructional technologists) have to work with. However, it should be noted that this is not a static field. Research is continually going on to determine the best screen size, resolution, background colors, brightness, etc. In the field of legibility, this type of research is referred to as "visibility" research. Its focus is to determine the characteristics that make a display and its symbols most visible.

Comprehensibility Elements

Comprehensibility screen design elements are those elements that a designer, publisher, or programmer can control. I use the term "comprehensibility" because the use of these elements effect the readability and, ultimately, learner understanding of the content. Isaacs (1987) states that

> The functions of a CAL lesson screen are to present information to a student and to evince and receive responses from that student . . . . we must also see that the student receives information of a facilitative nature—information to help the student use the system . . . . (p. 47)

Each comprehensibility element has a potential effect on the readability and understanding of the document. As Table 2 shows, there are a large number of factors. This number goes beyond the sum of discrete elements because of the number of combinations available. Five, six, seven, ten or more of these factors may be operating together at any one time in a display, compounding and confounding significantly the research problem.

It is an interesting area of study, because there seems no shortage of overall screen design recommendations on how to combine the comprehensibility elements. These recommendations are usually general heuristics, such as use lots of open space, use highlighting, be consistent between screens, keep one topic to a screen, keep the screens simple, and avoid clutter. (Isaacs, 1987; Kearsley, 1985; Lundeen, 1982; Ng, 1986; Rambally and Rambally, 1987).

Many of these recommendations are based upon research that examined the effects of single elements. For example, directive cues, such as underlining, highlighting, or bold type, facilitate search tasks; or, headings in question form, can facilitate learning of essential information. However, heuristics

Table 1
Technical Screen Design Elements

Typographic Factors

symbol height
symbol width-to-height ratio

Environment

glare and reflections
viewing angle

visual fatigue

symbol resolution

Screen Factors

dot matrix size
chromacity
contrast ratio
dot shape and spacing
flicker
resolution
horizontal symbol spacing vs.
dot generated symbols
stroke width
luminance

Many of the items listed in this table are from Dwyer (1985).

Table 2
Readability Screen Design Elements

Typographic Factors

line spacing
line length
leading (vertical line spacing)
size of letters
font characteristics
case of letters

Organization Factors

paragraph indication
graphic devices
figure/ground separation
headings

Cueing Factors

highlighting
color
case changes
graphic devices

Control Factors

icons
command bars
status bars
maps
scrolling

such as "avoid clutter," "use lots of open space," and "be consistent" are open to interpretation . These types of recommendations are usually based on folklore and design practices developed from the visual arts. Recommendations about the best ways to combine several elements still need to be researched.

Single Element Research:

As a result of research into the effects of single screen design elements, we can make generalizations about the uses of directive cues, headings, indentation, line length, type size, and leading. Originally, much of this research was based on print (hard copy[*]) studies, but the past years have seen more and more research aimed specifically on the application of these elements to video display terminals.

The focus upon video display terminals has helped provide suggestions for using attributes specific to screen displays. For example, color is a feature that is expensive to implement in hard copy, but costs nothing on color display screens. Tullis (1981) found that color-coding proved superior to narrative format when teaching adults to discriminate among different signals that required some sort of action or interpretation. On the other hand, Baker (1986) pointed up a significant problem with the use of a program designed to use color on a monochrome display. Baker found that children were unable to discern critical features of a color graphic displayed on a monochromatic monitor unless it was designed to enhance figure/ground separation.

Single-element research is extremely important in identifying the strengths, weaknesses, and potential problems of using specific attributes on CRT screens. There are a wealth of topics specific to computer displays that need to be examined: single and multiple windows, navigation aids, icons, scrolling, etc. Single element research is a necessary first step in understanding how to combine these elements into overall displays.

Multiple Element Research:

Despite research into individual screen design factors, there is a dearth of research into effects of combinations of these factors. Multi-element research tends to be more complex than single-element research. Examination of single text elements usually stops with that element and its effects on narrowly defined tasks. But the examination of combinations of elements involves not just the text elements, but the perceptions of the viewers also. It is not just a question of functionality, but cognitive effects as well. That the overall appearance of a screen has an affect on viewer preferences was found by Champness and DiAlberdi (1981) and Grabinger (1984, 1987). Champness and DiAlberdi examined the affects of informational screens used in an implementation of videotext for voluntary users and found screen preferences that were classified into factors labeled attractiveness, clarity, and usefulness. Grabinger had student viewers examine content-free models of screens intended for instruction classified viewer preferences into factors labeled simplicity, structure, and organization.

The main point is that the visual "gestalt" of a screen has an affect on learner preferences. These preferences are formed from perceptions, perceptions that may also affect cognitive processes. The next logical question, then, is whether this affective response also effects the processes a learner chooses to use while studying the material.

The processes and activities a student uses to learn are referred to as ***macroprocesses*** by Tobias (1984). Tobias defines macroprocesses as

> . . . those relatively molar cognitive processes students use when they learn from meaningful instructions, such as reviewing, previewing, looking for clarification, and the like. Macroprocesses . . . denote only the cognitive processes used by students to learn from instruction. (p.4)

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[*] **Hard Copy:** refers to paper documents, such as books or articles.

Tobias (1984) goes on to state that, "one assumption of instructional research in general is that alternate methods induce different types of macroprocessing (p. 5)."

The goal of research into the overall visual effect of the screen, then, is to identify macroprocesses effected by screen layout arrangements. Hopefully, by becoming aware of these activities, we can then identify specific designs to help control or enhance them.

The Problems of Research into the Overall Design of a Screen

And that brings up a major research problem. How do we identify the effects of a confusing combination of text elements and processes that are not physically visible? There are two main problems that arise with this question. First, the changes and effects of the appearance of a screen are molecular in terms of the overall instructional process. Second, as is always the case when trying to work with cognitive processes, the cerebrascope that examines the brain directly has not yet been invented, so research must rely on inferences.

For example, in a recent study (Grabinger and Albers, 1988) two fundamentally different screen designs were used in CAI programs for fourth grade students. One version incorporated plain text without color, graphic devices, highlighting, or other design enhancements. The other version was designed to incorporate indentation, highlighting, command bars, and boxes to make the screens appear more organized and structured. Dependent variables were immediate recall following the treatment, retention of material after a two-week delay, and average time spent on each screen. There were no differences between versions in recall or retention. There was, however, a difference in average time spent per screen with one of the enhanced versions. It was inferred from this difference in average time-per-screen that some different kinds of processing were occurring as a result of the altered screen design. It's an inference based on a small effect and one that is open to interpretation, but an effect that may stimulate further research.

Two possible conclusions may be drawn from this study. First, because of the lack of learning gains, it could be concluded that the overall visual design of the screen has little effect on macroprocesses. This is a possibility, because research regarding macroprocesses has discovered that students are not good at making decisions about which processes to employ or when to employ them. Lower ability students tend to employ learning strategies infrequently, while higher ability students tend to employ too many too frequently (Tobias, 1985)**. The design of a screen may suggest something, but it may not be explicit enough for most students. The purpose of design elements must be explained to students before they are encountered for them to have any effect (Fitzgibbon and Patrick, 1987).

A second possible conclusion is that the research methodologies and measures employed are not sensitive enough to measure the effects. In an effort to look at as many possible factors as possible Grabinger and Albers also added variables such as type of task (conceptual application or recall) and prior information about the screens. This may be a good multivariate design, but it also tends create so many cells in MANOVA designs that small scale effects become even smaller as degrees of freedom rise.

The basic argument is that we need to concentrate more precisely on the effects of screen designs on learner actions and processes, not just the major effects on learning. This is not to relegate the importance of learning to the closet. Learning, after all, is the primary goal of all instructional research. However, the point is that we must first identify ways in which cognitive processes are effected and then try to identify ways to control or to enhance them. It is only when we can exert some

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** Training students in the use of macroprocesses has positive effects, as does explicit instructions to use a specific type of strategy.

control over the processes that we can then make statements about how that control may be exerted.

Two examples of this effort to identify effects on smaller learner behaviors were described earlier in Tullis (1981) and Baker (1986). In their research regarding the effects of color they found significant features that will effect design decisions. They're measures of effect were on search tasks and perceptibility. Both of those dependent variables represent activities that are smaller activities in the learning process. If they had relied on gross learning instead of smaller actions such as discriminations and perceptibility, their research may not have found anything.

In another example, Haas and Hayes (1985) compared the ability of students to find previously read information in paper, CRT and, large CRT versions. Rather than using learning as the primary indication of effect, they used student estimates of target sequence and vertical and horizontal location. Their findings indicated that the more a student sees at one time and the less a body of text is broken up, the better they remember where material is located in the text.

What, then, can we use as dependent variables in investigating the visual effect of screen designs? Some of the following measures may prove useful:

> *Audit trails*. Implementations of hypertext and navigation options in traditional CAI programs leave users with a number of alternatives in how they "travel" through a program. Tracking a user's movements may provide information both about the program's and student's cognitive structure.
>
> *Eye movements*. Saccade amplitude and fixations provide physical evidence of a user's response to a specific design. This can provide information about the salience of specific design features, such as boxes, command bars, and hierarchical structures.
>
> *Time*. Time-per-screen and time-per-program may provide some indication of processing activity. This may be either positive or negative, for a design that is too complex may increase time because of cognitive overload. On the other hand, a design that encourages deeper processing of essential information may also increase the time a student spends with a screen or program.
>
> *Subjective evaluations*. User evaluations of screens in terms of helpfulness, aesthetic quality, organization, and structure are some of the qualities that may be used to provide information for the development of user-oriented screen design guidelines.
>
> *Search time and accuracy*. Specific tasks, such as searching for something specific on the screen can be measured in time and accuracy to provide information about the quality of organization or highlighting.
>
> *Generative and reproductive outcomes*. Outlines and graphic organizers can be used to get a subsequent "picture" of the effects of a design on a students own mental organization of the information.
>
> *Use of supplementary aids*. The use of help screens, maps, glossaries, and indices may provide some information about the ability of a screen to help elicit "investigatory" responses from the learner.

(This list is by no means exhaustive, but meant to stimulate thinking.)

The other problem in the research on the visual effect of screens is in the area of identifying the processes learners are using. This information is important because it may effect learning in both positive and negative ways. It is important to identify designs that may cause cognitive overload as well as designs that facilitate constructive cognitive behaviors.

In more operational terms, we need to identify measures that we can use to draw inferences about design effects on cognitive processes. Of course, this is not a problem solely in the realm of screen design, but a tough problem in all cognitive research. In investigations that deal strictly with learning strategies and macroprocesses, three methods have predominated:

1) post-lesson interviews of students about cognitive activities used in the lesson (Winne and Marx, 1982);

2) training of students in the use of specific strategies and then follow-up measures to identify the impact of that training on learning or learning tasks (Winne, 1982);

3) self-ratings by students on the amount of mental effort required for the learning task (Salomon, 1982).

All three of those methods may prove useful in the investigation of overall screen designs. Other techniques may be possible using generative and reproductive outcomes, multidimensional scaling, and factor analysis of audit trails and preferences.

Finally, after we find signs that certain types of screen designs effect student processing, then we must investigate the effects of those processes on learning. For example, if a highly structured screen design improves the quality of student outlines, has this supplanted their own processes and inhibited learning or has it enhanced their learning by improving their own organization? What kinds of students are these effects on? Is age important? What about training in the meaning of the features of a screen design type?

Conclusion

At this point in time, all we can say about screen design is that a well-designed CAI program teaches despite the design of the screens. However, this is something that can be said about most media studies and reflects that state of research in our field. We are at a point at which the focus of our research efforts is moving into the human mind. How can we help the mind function more efficiently and effectively?

We have broken the 4:00 minute mile. The improvements now come not in whole seconds, but in tenths of a second. We must design our research in such a way. We must look for the little things that make a difference in hopes that when we put a lot of little things together we will bump another tenth of a second off the clock. The task is to construct the kind of research that will allow us to infer that different designs will, in fact, lead to alternative cognitive processing for students. The intent of this paper was to stimulate discussion about a sequence and organization that will facilitate development of screen design research.

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Title:

Symposium: Interactive Video Symposium: The Singer or the Song--An Extension of Clark's Media Research Discussion

Paper #1: The Singer as Iconoclast: Six Arguments about the use of Video Disk For Teaching
Author: Richard E. Clark

Paper #2: Reflections on Why Media Comparison Studies Continue to be Conducted--with Suggested Alternatives
Author: Barbara Grabowski

Paper #3: A Discussion About Motivation
Author: Claudia Pask-McCartney

Paper #4: The Singer or the Song
Author: Michael Yacci

Paper #5: A Review of the Research on Interactive Video
Author: Elisa J. Slee

INTERACTIVE VIDEO SYMPOSIUM: THE SINGER OR THE SONG--AN EXTENSION OF CLARK'S MEDIA RESEARCH DISCUSSION

SYMPOSIUM CHAIR:

Barbara L. Grabowski

SYMPOSIUM PARTICIPANTS:

Richard E. Clark
Michael A. Yacci
Claudia Pask-McCartney
Elisa J.Slee
Barbara L. Grabowski

DISCUSSANT:

Clint Wallington

Symposium presented at the 1989 Annual Convention of the Association for Educational Communications and Technology, Dallas, TX.

INTERACTIVE VIDEO SYMPOSIUM: THE SINGER OR THE SONG-- AN EXTENSION OF CLARK'S MEDIA RESEARCH DISCUSSION

SYMPOSIUM INTRODUCTION

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Are media simply delivery vehicles as Clark (1983) has suggested? Do media really not influence learning? Is interactive video the one medium that will prove the age old argument presented by many of our leaders for the past 40 years wrong? Or, in fact, will interactive video be the one medium that will be spared from trivialized media comparison studies?

Since the late 70's when interactive video became a reality, many designers and researchers discussed whether its existence represented a "new" medium to be probed and researched to identify instructional prescriptions specific to this medium or whether it, in fact, was just another instructional tool (Hannafin, 1983, Grabowski, 1983, Grabowski & Pearson, 1988). During this same decade, Clark and others also revived an age old discussion advising that the important prescriptions will come from research on "instructional strategies" and cautioned against more trivial media comparison research (Clark & Snow, 1975, Clark, 1983, 1985, 1987, Clark & Salomon, 1987, Clark & Sugrue, 1988, Cohen, 1984).

When addressing the issue of the impact of the medium of interactive video on achievement, we felt that some of the inherent properties of a medium must be considered as McLuhan's (1967) tenet of "medium instead of message" would tend to suggest. The actual properties of the interactive videodisc itself will according to Cohen (1984) "ultimately dictate the essential form of the message transmitted on it and influence the way a student processes the information." While there is an obvious difference between a car and an iconic representation as McLuhan and Cohen suggest--is there any real difference between a car crash on videotape versus a car crash on videodisc? Using the same reasoning, we, then, consider this argument from the perspective of whether it is the "singer or the song" that will impact on our "learning" and motivation toward learning.

The purpose of this symposium, then, is to combine these two issues and reconsider this discussion in light of past, and current research on and with interactive video.

Included in this discussion are several points of view from a general consideration of Marshall McLuhan's the "medium is the message" to potential motivational effects of the medium. From this general point of view, we move to a specific review of past and current research on and with interactive video to determine if Clark's cautions are being heeded for this medium. Finally, the symposium concludes with some reflections on why media comparison studies continue and suggestions are made for possible appropriate areas for future research.

The symposium participants include:

Dr. Richard E. Clark
University of Southern California

Dr. Clark, the most distinguished leader in this discussion of the effects of media, also leads off the symposium. With the support of educational research, he presents "counter-intuitive" responses to six major areas of disagreement with regard to the use of interactive videodisc. His presentation sets the stage for the papers that follow.

Michael A. Yacci
Rochester Institute of Technology

Yacci attempts to bring McLuhan's issues to the forefront as he discusses Clark's argument and points out some different issues that have not yet been resolved.

Claudia Pask-McCartney
Syracuse University

Pask-McCartney extends the issues of achievement to issues behind what constitutes motivation and whether the medium affects motivation.

Elisa J. Slee
Syracuse University

The whole purpose of this discussion comes to light with Slee's presentation on the state of the research, as far as we could analyze in terms of reported research. She has taken the lead in reviewing the body of interactive video literature since 1983, and will present our findings from this review and analysis.

Barbara L. Grabowski
Syracuse University

Grabowski then concludes the discussion by considering reasons why we continue to see media comparison research reported in the literature. She, then, suggests areas for future research with and on interactive video.

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Title:

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The Singer or the Song--
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Paper #1: The Singer as Iconoclast:
Six Arguments about the use of
Video Disk For Teaching

Author: Richard E. Clark

THE SINGER AS ICONOCLAST:
SIX ARGUMENTS ABOUT THE USE OF VIDEO DISK FOR TEACHING

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Paper presented at the 1989 annual convention of the
Association for Educational Communications and Technology

THE SINGER AS ICONOCLAST:
SIX ARGUMENTS ABOUT THE USE OF VIDEO DISK FOR TEACHING

Richard E. Clark

University of Southern California

March, 1989

Concerns about the use of newer media in education have a very long and distinguished history. The Greek philosopher Socrates was reputed to have criticized the use of the "written word" in teaching. In his dialogues with the slave Meno, he claimed that only oral instruction, delivered by a skilled teacher, could draw out the natural knowledge possessed by all students. His objection to the new medium of the written word was that it would make students "lazy" and "destroy memory". While the written word is today established as one of the "traditional" media for education, many of our arguments about the adoption of newer media such as video-disk sound similar to Socrates' objections to the written word. For example, today there are at least six major areas of disagreement that seem to reoccur as new media are available for teaching. Those six arguments stem from questions such as: 1) is video disk more effective than traditional media (teachers and books) for promoting learning?; 2) Does the visual nature of video disk technology promote creative thinking?; 3) Does the capacity of the video disk technology to present more "realistic" instruction enhance student learning?; 4) Are students more motivated to learn from video disk than from traditional media?; 5) Does Video Disk and CBT connections increase freedom of choice by students?; and 6) Are media less expensive than teachers for some types of education and students?

What I find interesting about using educational research to analyze these questions is that the best current answers to many questions are often "counter-intuitive". The best current answer to each of the six questions is considerably different than I had expected when I began my research.

1) Is Video Disk Technology More Effective In Promoting Learning Than Traditional Media?

The best and quickest answer to this question is "yes"... and "no". Yes, the research in the United States, Canada, Australia, Indonesia, Columbia, El Salvador and the United Kingdom provide dramatic evidence that television (and other new media) increase student learning an average of 20% over more traditional means of teaching. Once the video disk is more established we will probably find a comparable measure of effectiveness. But there is no evidence that the medium used causes the learning gains. Instead, the school achievement gains are probably due to efforts that accompany the introduction and use of new media such as curriculum reforms, increased investment of resources in designing lessons and in preparing students for instruction. It takes teams of specialists to develop, produce and present a video disk teaching program. Yet, newer media serve as an important "context" in which governments and educators increase the effort and resources invested in education. There is more agreement now among researchers that the same learning gains we measure from newer media would also be possible with traditional forms of instruction -- though our teachers have had a very difficult time adopting to newer methods of teaching.

Of course one of the claims made about newer media such as computers and video disk is that they allow for "interactivity" between student and teacher. While that may be true, other media including the oldest media -- teachers -- provide the same capacity. Video disks do not provide any form of interactivity which cannot be duplicated by existing technologies even though such a duplication in the case of certain instructional messages would be much less efficient.

Therefore, it seems that media are carriers or "vehicles" that transport instruction to students. The instruction carried my any media, new or old, might be effective or ineffective. This was the source of the analogy I used in my 1983 Review of Educational Research article, that media do not influence student learning any more than the truck that delivers groceries to a market influences the nutrition of the market's customers. But media are interesting and they attract the interests of educational reformers and workers. Newer media present the opportunity to lure more resources to education, and they permit the use of newer instructional methods that teachers either reject or are too busy to use. The greatest advantage of the new media is that they adopt so quickly and easily to new developments in Instructional technique and curriculum change. They also have a capacity to perform instructional tasks that teachers either dislike or are unwilling to learn.

2) Does the visual nature of video disk promote more creative thinking by students?

Based on the great volume of research conducted in this area, the answer is clearly "no". Yet, there is good evidence from interviews with famous artists, writers and scientists that mental imagery is important for creative thinking. Albert Einstein, for example, reported gaining insight into his theory of relativity when he imagined himself being transported to the moon in a Viennese cable car. As the car approached the speed of light, Einstein recounted his surprise that the car became narrower and that time within the car slowed down relative to the time back in Vienna. Accounts such as this fuel our imagination and our expectations for the power of visual thinking. However, visual thinking might help creative thought (particularly for the educated scientist or accomplished artist) but there is no evidence that visual media increase or enhance visual imagery. In fact, the evidence suggests that one does not have to have strong visual imagination to do the most creative thinking. Many creative thinkers use verbal means to "imagine" ideas. There is even evidence that using pictures during reading instruction may interfere with the initial reading skills of children who are slow to read.

Why then does visual instruction seem to be such a powerful tool for education if the research evidence does not support its use? It appears that the formation and use of mental visual images is not necessarily helped by visual instruction but under some conditions, visual images seem to enhance thinking and problem solving. Visual imagery seems to be a talent that some of us are born with and others are not. People who are not able to have visual images find other means, mostly verbal, to represent visual events in their minds. In fact, a recent major study of visual imagery and visual problem solving found that highly verbal students with very low visual ability were just as successful as the most visual students in solving *visual* problems. This was a "counter-intuitive" surprise to many psychologists. Investigations about why the non-visual students were able to solve visual problems suggest that they made good use of analogies and metaphor. It is my view that the advantage of visual imagery is that the "pictures in our minds" serve as a very powerful analogy of the problem being solved. In Einstein's trip to the moon image, the cable car was a convenient and concrete analogy for the three elements of the theory he developed - mass, velocity and energy. Such creative thinking may actually require the use of analogies, some of which are visual.

The practical application of this area of argument is to notice that we need to make greater use of analogies in all of our instruction. A recent study found that there was only minimal use of analogies in the textbooks and other instructional materials for teaching of mathematics and science. Yet, it seems that the use of concrete imagery greatly helps creative thinking and speeds up learning about complex concepts. We should keep this in mind when we develop new or traditional instructional media.

3) Media such as video disk present information that is more realistic. Does that enhance student learning?

During the 1950's and 60's in the United States there was a very famous theory called the "cone of experience". This theory suggested that the closer instruction came to depicting the way events were experienced, the more learning that was possible. This "realism", we argued, was not available in the artificial environment of most classrooms but it was available from movies and television. For example, many educators notice that the printed word only presents the student with "abstractions" of experience, whereas television and the cinema provide information to a variety of senses in a form similar to that encountered during an actual experience. The theory seemed sound because it was intuitively correct to a number of educators, myself included. Yet, there is no research evidence in favor of the theory and a considerable amount of evidence against it.

Why should realism not support learning? While there may be settings in which realism is helpful to learning, we have not yet discovered them. The psychological research on this subject suggests that "realism" adds many attractive but irrelevant parts to an instructional presentation. Students who are beginning to learn a new subject or who have difficulty learning seem often to be distracted by the irrelevant aspects of realistic presentations. The most effective instructional presentations for new or slow learners is one which helps focus their attention and thinking on a few relevant concepts or principles. For the more advanced student, realism seems to neither help nor hinder learning.

4) Are students more motivated to learn from newer media such as video disk than from more traditional media?

The quickest answer to this question is an enthusiastic -- yes. The motivation encouraged by newer instructional media seems to be common in a great variety of nations, cultures and different types of individuals. This same enthusiasm seems also to be shared by the parents of students. This enthusiasm, I believe, accounts for some of the increased learning we find with some of the new media. Yet, even here there are two exceptions: 1) this motivation seems to diminish quickly; and 2) students seem often to be wrong about the effort it will take to learn from certain media.

One source of my claim that student interest in new media diminishes over time is the large number of research studies that have asked this question. In this research it is generally found that motivation decreases as the amount of time spent with a new medium increases. After one year with televised instruction, for example, most students are only as enthusiastic about it as they are about other alternatives. This same result is true of computers and the new video disk technology. While this decrease in motivation may be partly due to the poor quality of many instructional media presentations, I doubt that this is a significant factor. Generally, familiarity with media seems to bring acceptance but motivation decreases with familiarity.

Much of the reason for this motivational decrease, I believe, stems from inaccurate student beliefs about certain media. Some of the most exciting research being conducted at the moment, explores the effects of student expectations and beliefs about media. One of the most dramatic early results of this research is the finding that students think that some media are much less difficult than others. For example, students seem universally and wrongly to believe that books are much more difficult a source of information than is television. Their belief stems from the fact that in most nations, television is a source of light entertainment and current events. Books seem more demanding by virtue of their traditional content for the student. Students reason that television makes learning easier and more entertaining. This is the initial source of their increased motivation towards it. Yet, a moment's reflection will establish that there is nothing about the written word that is necessarily more demanding than television. To a psychologist, it appears that students often use television in a "shallow" way. Whereas they are taught to read books they are not taught to "watch" television. This is the origin of the recent interest in "media literacy" training in a number of nations. We need to give more instruction to students on how to learn from new media.

The obvious problem with these beliefs is that many students will not invest enough intellectual effort to learn from "easy" media such as television. Less obvious is the fact that students seem to believe that computers are very difficult learning tools. Some students seem frightened and think that the new medium is excessively difficult. Literacy training, when it is successful, provides students with strategies for learning from new media. These strategies, when applied over time, eventually convince the student that no one medium is any more difficult or more easy than another for learning. It is the content of the medium that imposes difficulty on learning, not the medium. This may be why motivation for new media decrease over time until it equals motivation for more traditional media.

5) Do media such as video disk increase the freedom of instructional choice by students?

Nearly all psychologists would agree that different students learn best from different instructional strategies. This fact has been the force behind our interest in "individualizing" instruction, particularly at the university level and in some large, urban secondary schools. On the simplest level, students are allowed to choose, for example, whether they wish to attend lectures or to later listen to an audiotape of the lecture. On a more sophisticated level, individualized instruction involves the development of an entire course of study through specially designed workbooks, television programs and/or slide-tape presentations. These developed courses are offered as alternatives to the traditional lecture by a professor. Generally, students like to have choices. In American universities approximately half of the students offered these choices elect the "individualized" media. It is thought, though not yet established, that such freedom of choice increases student motivation to learn and the intelligent effort they will spend on their own education.

However, there is a problem with this increased freedom to choose. Research by psychologists in the United States has established that some students seem to make the wrong choice for themselves. The most capable students who should choose the traditional instructional media (which is often less structured), instead choose the newer media (which is often more directive and structured). On the other hand, less capable students often choose the traditional lectures when they might learn more from the structured, newer media and teaching strategies. The reason for these less-than-perfect choices on the part of students is a misunderstanding of the consequences of their choice. More capable students believe that the more structured instruction will make their study more efficient and give them a better chance on their examinations with less effort expended. Less capable students seem to like the freedom of the less structured media though they do not learn as much. In some cases, they have the freedom not to expend so much effort and yet receive lower evaluations. So, while alternative media do provide more freedom to students and while they like this freedom, they do not always benefit from it.

Of course, it is possible to assign students to these new instructional programs which use the newer media. One of the more successful and dramatic successes of this approach is the Netherlands where one of the medical schools has changed its curriculum for the education of physicians to an individualized, problem solving approach. Instead of the traditional lectures and reading then examinations, this school gives students carefully planned problems to solve. Evidence in that nation suggests that medical students taught by this new plan are outperforming traditional students on all tests -- even though they are randomly assigned to the school.

6) Are video disk less expensive than teachers for some types of instruction?

The final question, about the cost of media, may seem to belong more to the study of economics than to psychology. Yet, assessing cost in education must involve the relative learning benefits of different kinds of media. Psychology investigates learning while our colleagues in economics are concerned with theories of value and market. In answering this question I am indebted to a number of economist colleagues. I will briefly present some of the conclusions of the economic research on two new media, television and computers:

There is good evidence that televised instruction can be made very inexpensive if its use is spread out over a great number of students. The current estimate for the cost of our very successful children's television series, Sesame Street, is about $.50 US per viewing child, per year. Considering the evidence that this program helps our children learn to read faster, the cost is low. This may be one of the reasons why Sesame Street has been translated into over 20 languages and has been acquired for broadcast in many nations. Most important was the decision of the producers of this program to develop their programs using teams of teachers, psychologists and artists. Television is increasingly interesting as a delivery medium for education in nations where economic hardships prevent the building of adequate classrooms or the training of sufficient numbers of teachers.

Recent studies show that computerized instruction is seldom fully utilized in any school. We have learned that computers and other media take a great deal of effort to successfully blend with other school activities. If fully used however, the cost of computers for instruction is much less than most of us had expected and its learning benefits are potentially greater if adequate instructional programs are used. One interesting result of our research is to note that the cost of the same computerized instructional program may change a great deal between schools and between nations. We think that this may be due to the way in which schools implement media and with the attitude of teachers. There appear to be some management and organizational plans that are more efficient and effective than others for the production and use of new media.

It may also be possible that video disk technology will be a much more efficient way to provide interactive teaching. At the moment there is no compelling evidence for or against the claim of efficiency. In fact, Henry Levin at Stanford finds that for most purposes requiring interactivity in teaching, teachers aids paid at minimum wage levels were much more cost-effective than computers. Why should we not find the same thing to be true with video disk and computer marriages?

Conclusion

As a researcher, I remain committed to the use of media in education. When combined with supportive teachers, carefully planned lessons and a sympathetic educational system, it can be very effective and inexpensive. I think that it is very unrealistic (but interesting nonetheless) to consider what an educational system would be like if it were primarily delivered by newer media. Yet I am most interested in the possibilities of media to solve some of the problems of developing nations and the children of the poor. It is clear that we have not yet achieved a fair distribution of educational benefits in the third world, nor in some of the minority groups in the first world. These children of the poor require high quality instruction if they are to take their rightful place in their own communities. The technology of education which has been developing these past two decades could, if properly implemented, provide one critical part of the incentive these children need to obtain an education. In this regard, I am impressed with the progress being made in using media by nations such as The Peoples Republic of China, Indonesia, India and Mexico. Many of the problems encountered in these new media programs show us that the "transfer" of technology between nations is a difficult task. It requires a great deal of communication and honesty. For those of use who specialize in research and theory, it requires most of all a willingness to let our rational and substantive concerns about learning from media control our enthusiasms.

Title:

Symposium: Interactive Video Symposium:
The Singer or the Song--
An Extension of Clark's Media
Research Discussion

Paper #2: Reflections on Why Media
Comparison Studies Continue to be
Conducted--with Suggested
Alternatives

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REFLECTIONS ON WHY MEDIA COMPARISON STUDIES CONTINUE TO BE CONDUCTED--WITH SUGGESTED ALTERNATIVES

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In this portion of the symposium, I would like to present some thoughts on why we continue to read media comparison studies when the reasons for NOT doing this type of research have been widely documented in the literature for many decades. I felt that facing these issues from this perspective may shed some light on how to stop the trend, so we stop wasting more effort and opportunity especially where interactive video is concerned. Surely only by understanding the problem can we suggest some alternative approaches to studying how people learn, using media or more specifically computer based interactive video, as a research tool. Hopefully, with this understanding, we can attempt to eliminate the motivation that entices us to continue conducting this type of research.

So, why are we enticed into conducting media comparison studies to determine the relative effectiveness of computer based interactive video (CBIV)? To set the stage, consider three very common scenarios.

First, a government official enters your office and wants to know all about interactive video. He/she states, "We are considering buying interactive video for training health care providers. Tell me, is interactive video effective? For what types of learning is it effective? Is it better than stand-up lecture for teaching procedures? And what about cost? Is it cost-effective? Are there studies which can unqualifiably state that it is effective?

Second, you read an article of some well designed research study in which the researchers use CBIV to test whether X instructional or motivational strategy enhances learning and find significance. The results are well described, but in the introduction and the summary, they are misrepresented; the researchers state that their results show that CBIV is effective!

Or, finally, a doctoral student enters your office and says that his/her administrator wants to explore the effectiveness of CBIV. This student just so happens to have a pre-packaged CBIV lesson and wonders if adding this lesson will affect transfer of learning. She/he proposes a simple, quick study which sets up a comparison of traditional lecture and CBIV with an extended traditional lecture to "measure the effectiveness of CBIV."

In Scenario one, the "motivation" is a plea from administrators for data to help them make informed decisions about major budget expenditures. Compare this to the question, "Are flipcharts effective?" Administrators are not asking this type of question because the answer is not as critical to their job (and job security). Although the question implies it, administrators really are not concerned with whether or not this medium will be effective in one situation versus another. In other words, they are not concerned with making micro media selection decisions, but rather with making macro media acquisition decisions. Media comparison studies offer answers to micro media selection questions, although they appear to offer answers to the macro questions. Whereas the research may show the treatment used on CBIV was effective, it was effective for one specific population, content area, and instructional strategy used, and the results do not offer that "guarantee" that administrators would like to have.

In Scenario two, the "motivation" is the temptation to extend the results of one's study to provide the global answers to those direct questions from administrators in scenario one. The need for answers to the media question is very great, and researchers who use media appear to have high demand results. What happens too often, unfortunately, is a misrepresentation of one's research results. What is even more unfortunate is that some researchers are not even aware of this misrepresentation.

In Scenario three, the "motivation" is the ease with which studies like this are conceptualized, conducted and analyzed. Deep, concentrated thinking to determine the true factors which are having an effect takes a great deal of effort and time. Students hear advice to first just get a study done to meet the degree requirements, and then go out and do something significant and important. Although I am realistic, I have serious concerns with this approach--the main problem being that students repeat what they know and have practiced. What results is a continuation of loosely conceptualized research, and a proliferation of trivialized media comparison studies.

What is implicit in these scenarios is that administrators need data on the main question, "is CBIV effective?" Simple-minded media comparison studies (practiced at first as a doctoral study) seem to provide them with easily obtainable data, and research which uses the medium, albeit as a research tool, translates easily into a response to that question.

For scenario one, we must help administrators either 1) rephrase their question, or 2) appropriately interpret the question they are asking. If we eliminate the question, then we will also eliminate the temptation to extend research results inappropriately to address the effectiveness of a medium issue, as we so often see as noted in scenario two. While we may never be able to eliminate the third scenario by making research easier to do (nor would we necessarily want to), we must take the leadership by not allowing the types of studies noted in scenario three to be practiced by doctoral students.

For rephrasing or reinterpreting the question, I feel that there are two underlying questions which are integral to the scenarios. "Is interactive video effective?" and, more importantly is CBIV cost- effective? Both of these questions concern me, because the first implies one right answer to a very global question, and the second implies a comparison.

For the cost effectiveness issue, I quite heartily agree with Clark that we need to conduct more studies which compare media from an economic standpoint. This seems so obvious, that it makes me wonder why there are not more researchers focusing their efforts in the area of economic analysis. What is important, however, with this approach is to emphasize to adminstrators that when they ask the question about CBIV effectiveness, they really need data on its cost, especially where these more expensive media are concerned. The effectiveness issue is another story and needs to be dealt in a much different way and, therefore, will be the focus of the remaining portion of this paper.

How would one answer such a question as "Is CBIV effective?" that administrators are asking. Given the arguments laid out by Clark and others (Clark, 1983, 1985, Clark and Salomon, 1987, Clark, 1988, Clark and Sugrue, 1988.) in the last few decades, my response would be, "Of course, interactive video has the potential for delivering effective instruction." Implicit in this response is the fact that interactive video can also deliver very ineffective instruction.

To identify areas for research on learning with media, we should consider what factors might allow or prevent the medium from reaching its potential for delivering effective instruction. I divide these enabling or prohibitive factors into 2 categories: non-media related factors and media related factors.

For non-media related factors, interactive video will deliver effective instruction depending on

1) the appropriateness or inappropriateness of the instructional and motivational strategies used.

2) whether or not the medium delivers instruction which takes individual differences into account. Since this item is often subsumed under factor one, and thereby often ignored in research and design, I felt that it warrants a separate listing.

3) the appropriate organization of symbol systems which cultivate cognitive skills, or, in other words, appropriate message design.

For media related factors, two factors emerge. Specifically, then, interactive video may deliver effective instruction depending upon

1) whether the CBIV medium has the capability to carry the selected instructional, motivation and message design strategy.

2) whether there is medium/individual belief interaction.

By rephrasing the question "Is interactive video effective?" to "Does CBIV have the potential to carry effective instruction?" and by considering the factors that may prevent the medium from delivering effective instruction, I feel that the emphasis is shifted away from media comparison to considering the question in the spirit of Clark's argument. This shift in emphasis denotes three very important and interrelated areas of study.

1. "instructional and motivational strategies" research,

2. message design research, and

3. Intra-medium studies (medium specific studies).

The essence of Clark's argument lies in the first of these three factors in that it is the instructional design that makes a difference in learning rather than the medium. This is the clearest and most well documented of all the factors, and so I won't elaborate on this issue here except to state that in this area CBIV offers tremendous potential for functioning as a research tool because of its data collection capability, its standardization of treatments, and automatic randomization capabilities.

If instructional, motivational and message design strategies are the main determining factors of a lesson's effectiveness, then the next step it seems is to study the medium's attributes and symbol systems to determine its ability to actually relay these designated strategies. Selecting a medium which cannot deliver the design strategies is like asking a non singer like myself to sing a song, or trying to carry a couch in a Volkswagen Beetle. In both cases the "message" gets carried, but the quality of the received message has been impaired by the "medium's" capability no matter how solid the design. In other words, by understanding the medium's capability to deliver the specified instructional, motivational, and message design strategies, we won't be asking a non-singer to sing, or having a small car deliver too large of packages. What is implied here is to study the capabilities of the medium NOT to determine its effectiveness one over the other but rather to determine which of the design strategies it can carry. The purpose of this study would be to create a matrix which matches design strategies with specific media attributes and symbol systems. We know a great deal about the media that have been around for decades, but I don't feel that we fully understand the capabilities and symbol systems of the newer technologies as to their ability to carry some of the newer instructional strategies being suggested by the shift in emphasis to a cognitive versus a behavioral approach to learning.

One potential outcome is the identification of clusters of media attributes that cultivate cognitive skills. Clark in his 1987 address to AECT, acknowledged the potential of this approach, but remained skeptical because of the trend of this research is to find the "one" right media attribute that would indeed cultivate cognitive processes. Again, I am not suggesting that one attribute may be better from a comparison point of view, but rather that it is important to identify which ones may have that capability. The most prevalent medium which may possess those unique attributes is the computer because of its ability to emulate human cognitive processing (Kozma, 1987). Exploring the medium's potential attributes in light of the current thinking and research on generative strategies and adaptive instruction leaves me yet unconvinced that all media attributes can facilitate all types information processing by all types of learners.

An excellent example of this type of research is suggested by Kozma (1986, 1987) of Michigan in two reports--one on computers and one on video. He contends that the computer's ability to emulate human cognitive processing may supplant lacking cognitive strategies and in turn reduce the load on short term memory/ working memory and thereby increase learning. Studying CBIV as a medium to deliver instruction may contribute to our knowledge on how individual's process information and vice versa. This signifies to me an iterative, interactive and synergistic process. If we didn't study the attributes perhaps the means for delivering various strategies may be left undiscovered. Again, I find this especially true as we rethink the use of generative strategies.

The second media related factor is a medium/individual belief interaction. While I would agree with Clark that the individual holds the belief, those belief systems are caused by some external event. This factor is especially important with the increased use of computers and the phenomenon of computer phobia. The best design ever delivered via a computer will not communicate its message to someone who sits in fear of it or who has a disdain for the impersonal nature of the medium. Clark does not deny that this phobia exists, he has just identified the problem as being within the individual rather than being the medium than makes a difference. My suggestion as to how to view this factor is as an interaction between the individual and the medium--with both contributing to the resulting ineffective instruction. This implies identifying the factors both about the individual and the medium that may cause such a reaction. By learning about one, we can contribute to our knowledge about the other.

To conclude, by studying the interaction of strategies/media attributes of CBIV/individual beliefs, we may better be able to respond to the administrators in Scenario one by stating "CBIV has the potential for delivering effective, motivating instruction because it can deliver these types of instructional strategies which have been shown to be effective for these types of learners.

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Title:

Symposium: Interactive Video Symposium:
The Singer or the Song--
An Extension of Clark's Media
Research Discussion

Paper #3: A Discussion About Motivation

Author: Claudia Pask-McCartney

A DISCUSSION ABOUT MOTIVATION

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Paper presented at the Association for Educational Communications and Technology annual meeting, February 1989, Dallas, TX.

I basically agree with what Richard Clark has said today, and just as he has emphasized expectation and beliefs in relation to motivation, I am going to present my expectations and beliefs about motivation and what is motivating. My own beliefs are that Dr. Clark's discussions of the importance of knowing about cognitive and design issues are actually discussions about motivation.

For me, learner motivation, with its myriad of subconcepts, includes all issues relevant to learning and instruction. It is the pivital factor in education, no matter what medium is employed or how it is used. I would, however, add that there may be some media which do make specific contributions in some situations in efficiently and effectively influencing learner motivation in a positive manner--some more than others in comparison, both in reality and in promise. In other words, motivation is key, but the medium may influence that motivation.

If, as defined, motivation includes all factors which arouse, sustain, and direct behavior (Keller, 1978), then we can say that the study of the construct of motivation is the study of all of the antecedents, all of the processes, and all of the consequences of learning which link all of the individual's feelings, thoughts, and actions in learning. The beliefs and expectations which Richard Clark noted in his presentation represents only a small subset of the total motivational states of the learner. All of this implies that in our research, we must look at the motivational state of the learner in interaction with the instructional method (Clark, R. C. and Clark, R. E., 1984). I regard this question of interaction as valid and important, and I would place special emphasis on the value of finding the answers for our attempts at inducing learning.

Indeed, Clark and his colleagues have identified many issues which I categorize as motivational factors that go beyond what he has included in his statement in today's presentation. For example, they have considered the novelty effect of certain media methods (Clark, 1984), the role of learner stress, anxiety, and worry in learning (Freeman & Clark, 1985), the presentation of feedback in terms of the self-efficacy theory (Vlau & Clark, 1987), and the orientation of the novice versus the expert learner in terms of attitudes, experiences, and aptitudes as they relate to design issues of task difficulty, attention focusing, choice, and to instructional delivery methods (Aster & Clark, 1985, McGowan & Clark, 1985). In addressing these issues, they are investigating the interaction of design and delivery methods with personality and experience.

After many years of examining motives and motivation and what they mean in psychology and learning, my own particular bias is to find out what motivates individual students to learn and to determine how to enhance and develop this motivation. My efforts are directed toward investigating three general goals for learning. The first goal is motivating the learner to attend and participate in the learning activity; the second is motivating the learner to achieve both the designated learning outcomes and positive attitudes toward the content and process; and the third goal is continuing motivation, or helping the learner apply the learning in present and future situations. After surveying the general motivational issues--which I feel include every factor involved in learning--I conclude that, in order for a designer to fully accomplish these three goals, it is essential that we have a thorough understanding of the learner's personality as well as his/her feelings and cognitions about him/herself, others, the medium, the task and the demands of the task. Only by having this understanding can we deliberately plan, design, implement and adapt a motivational delivery program for every lesson which accomplishes or at least encourages the attainment of the three goals I have mentioned. This suggestion holds true for any and all instructional media and methods applied.

The first point I wish to make, then, is not so much one of designating which instructional medium may be the most motivating by comparing one to another and asking "why," but one of deciding what the motivational issues are, for whom, when, and whether or not they are truly being addressed by designers in an other than haphazard way. Do we actually see all aspects of learning in terms of motivation? Do we actually take every factor into account, assess and know the individual learner in regard to the factors, and do we, in reality design lessons, for any medium, which then cultivate motivation and encourage learning? Or do we simply depend upon the content to have an inspiring effect on some learners, or on the learner's own efforts to make the tasks enjoyable for themselves? Further still, are designers relying on certain media such as CBI and video to offer that novelty effect mentioned by Clark and to therefore "be motivating"? Because of what designers may or may not do, the question for researchers becomes not one of comparing the motivational value of differing media, but how much do we know about the person and instruction, the interaction between the two, how can we learn more, and how will we deliberately encourage the use this information in design and delivery.

My second point is, given that a motivational delivery program can be planned, designed, implemented and adapted around each content and learner, how can it best be implemented on each medium to determine if there are certain media which could deliver this program more effectively and efficiently than others?

Throughout my discussion, I have been agreeing with Dr. Clark when he says that the learner's beliefs and expectations are important in their approach to a medium, as is the study of the interaction between the student's motivational state and the instruction. I have, however, expanded the importance of the construct of motivation, which includes a comprehensive set of all learning factors, that motivation can be learned, and that we should deliberately design for the enhancement of positive motivational task accomplishment and attitudes for each student. Certain factors already seem clear from the research on what contributes to positive motivation. These are: Clear and realistic goal setting; clear task boundaries; choice; incremental task accomplishment; responsive leadership and active learner participation; energetic, enthusiastic presentation; a knowledgeable and approachable teacher; the setting of positive expectancies for success; a climate of trust, openness and acceptance; moderate novelty and surprise; needs assessed and met; acceptance of failure and encouragement of risk-taking; and properly executed reinforcement and reward. In our quest to delineate what will succeed with what learner, we should not overlook the idea that there may be media which have more potential than others for delivering strategies directed at accomplishing a true and positive learning experience which incorporates those factors listed above. There may be some media which can more fully deliver "motivational designs." In theory, this should not be necessarily so, but in practice, it is worth thinking about.

If, as Clark suggests, lessons are more carefully designed for technical media, then maybe we should begin to design deliberate motivational elements for such media. For example, it has been documented that consistency, relevancy and reward are important in directing motivational learning. This can be well accomplished in design for education via various media. If, also, adaptation to the individual's motivational state is considered important in learning, then a computer may best be able to include assessment devices and constant monitoring of changes needed to keep the student interested and engaged. While teachers generally hope to motivate students, and understand motivation, they seldom have the time to adjust learning for each person they instruct. I suggest, in addition that "machines" may be "best" at helping teachers to enhance motivation. Teachers themselves will have more time to know the individual learner in terms of their wants and needs when they are freed from some of the obligations of delivering all of the content.

Although I do not wish to be comparing media with regard to these issues, I do wish to say that CBIV, in particular, is a medium which has outstanding potential for delivering programs which have been motivationally designed. CBIV offers a cluster of attributes which may effectively combine instruction with motivational elements to encourage learning. It is a responsive and participative medium whereby the motivational design elements can be consistently and fairly applied, choices offered, databases for a richness of relevant examples and practice quickly accessed, and learner needs recorded, monitored and adapted. CBIV is a multi-sensory approach to learning which may vividly portray "the human qualities" of the enthusiastic, caring, knowledgeable teacher. Thus, with CBIV, the designer has an outstanding opportunity to incorporate the strategies which encompass those factors which researchers have identified as contributing to a positive motivational state for the learner.

It would be my hope that this medium, in particular, be explored as to how it can display material which enhances learner motivation. Equally important, to me, is the research on learning-- on the interaction of the student's motivational state and the instruction--which can be conducted using the potential of CBIV as a research tool. By using this medium in this way, and by not focusing on comparing this medium to others, we may discover more about what works for whom, and when and create strategies that motivate students to learn and care about that learning, strategies which can transfer to other media as well as enrich our capabilities to educate.

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Title:

Symposium:	Interactive Video Symposium: The Singer or the Song-- An Extension of Clark's Media Research Discussion
Paper #4:	The Singer or the Song
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AECT Presentation
February, 1989

The Singer or the Song

A COMMON SENSE APPROACH

This presentation is offered as an extension of Richard Clark's position regarding media. Through this paper, I hope to translate Clark's argument into practical terms, and point out some different issues that have not yet been resolved.

Clark has been the strongest advocate of a particular point of view regarding media--that media make no difference in student achievement. In other words, the medium itself is not a significant contributor to achieving the ends of learning, but rather instructional strategies--the particular ways that instruction is assembled and the components thereof--are the true independent variables in a learning situation. Clark has stated that media are "mere vehicles" that can be used for the delivery of instruction--but are not required for learning.

Clark has cited numerous research studies that have failed to control for the effects of instructional strategies. Essentially these studies have compared educational "apples with oranges," and consequently these studies are suspect to a confounding effect, that is, the notion that there could be other, equally rational reasons for any given difference in achievement. Clark claims that previous media comparison studies, which tend to turn up with the emergence of any new media/technology, all fail to control for the effect of instructional strategies within different treatment groups.

Obviously, then, these "media comparison" studies that Clark cites, are really *not* studies that are designed to compare the effects of media in instruction. Since they use different designs, instructional components and sometimes different symbol systems, they are essentially studies that compared the effects of different *mediated instructional designs*--but not different media.

From a "pure" research perspective, it would seem that Clark is correct in his conclusions. Adding Salomon's notion of symbol systems--the various ways that information is encoded--would suggest that if we controlled for different symbol systems along with different instructional strategies, then we might seemingly have a media comparison study that would be valid. Comparing the amount of cognitive learning when identical instructional strategies and symbol systems are used should logically produce no difference in achievement. What might such a study look like? For example, one group could be given several paragraphs on paper to read, while a second group is given exactly the same material, except the second group has the material projected on a wall using a slide projector. An achievement test would probably show no difference between the groups--in other words, the medium would have made no difference in such a learning situation. Now, perhaps changing the symbol system would make a difference. For example, if one group *read* the paragraph while a second group *heard* an audio tape of the information. Of course, if a difference in achievement occurred, it could be due to the different symbol systems that were used, not necessarily the medium that carried either symbol system. While this logical type of "thought experiment" really doesn't confirm Clark's conclusions, it brings home the common sense side of his position. Indeed, in such an experimental situation where both symbol systems and instructional strategies are held constant, it would be remarkable if there was a significant difference in achievement.

My goal today is to agree in principle with Clark's position, but to extend it to consider alternative ways of thinking about media regarding the difference media **do** make along with the difference that they **can** make.

I would like to take a somewhat logical look at two major areas. These areas are the differences between cognitive and affective learning outcomes, and the differences between common usage and potential of a medium.

COGNITIVE AND AFFECTIVE OUTCOMES

Clark's famous and often quoted analogy equates media and instruction with food and the truck used to deliver the food: the medium that delivers instruction will have no more of an impact on student achievement than the truck that delivers food will have on the nutritional value of that food. In other words, media are "mere vehicles" for the delivery of instruction.

I would like to offer a different analogy that might lead to a different conclusion: the singer and the song. That is, at times the medium is as important as the message--and at times more so.

Music business people generally agree that the best way to sell records is not through massive airplay, but rather "putting the artist on the road." People tend to like musicians that they have seen perform live . This explains why musicians still tour despite the sophisticated mass communication technology currently available. Now, it is interesting that a member of the audience can like a performer but be unable to restate any of the lyrics to any songs. Hence, the audience may not be perceiving any cognitive message at all. But through real "contact" with the artist, a change in attitude or belief occurs. This points to the real key to this analogy--there are definite affective and cognitive differences between mediated music and live music. And there are differences between mediated instruction and live instruction.

A song is really "content" delivered by a singer, the same way that instruction is delivered by a medium. Is there a difference between Frank Sinatra and Frank Schwartz? That probably depends on if you're a Sinatra fan or not; if so, then there is a major difference in "mere" delivery vehicle!

A *fan* would be happy to hear Sinatra sing anything--so a fan will attend to any content that is presented, simply through his affect toward the vehicle (Sinatra). To others, it may be the song that is important. "My Way" might be a song that interests them--and they may be totally oblivious to the performer.

If this analogy holds true for instruction, then we might conclude that certain media can evoke attention simply because of a student's continuing and previously learned affect for a medium. Was there a difference in your own attending behavior when Dr. Clark was not here in person today? While you have been exposed to the same symbol system of spoken language, some people's attention may have wandered because the **real** Richard Clark wasn't here. You wanted Sinatra--you got Schwartz.

Clark speaks of this effect in terms of attribution theory and claims that attitude toward medium is not a media attribute, but rather a learner attribute. My thoughts on this say that if using a different medium will produce greater attention, then this is indeed correlated with the medium, and should be considered a media attribute.

Of course the flip side may also be true--a strong negative affect for any medium may destroy motivation and interest. How many people tend to groan when a teacher or trainer pulls out a stack of transparencies and approaches the overhead projector? How many people have a fear of innovation and would rather not approach CBT or Interactive Video because of their fear of the medium itself? In like manner, no matter how great a voice Mohmar Khadaffi has, not many Americans want to hear him sing "Strangers in the Night." So the delivery vehicle can interact in a distracting emotional way to affect cognitive learning.

A recent study was interested in the effect of a program to help shy women start and maintain conversations with men. The delivery vehicles were both CBT treatments and text-based treatments. Although the women learned slightly more from the text-based treatments, there was no significant difference between the two. While this study points to Clark's "no difference" conclusion, it *didn't* explore the possible differences between *live* instruction and any form of mediated instruction. It would be a logical hypothesis that a male, human instructor might significantly change the achievement levels of the learners, either for better or for worse.

Clark has identified a positive affect toward innovation as a "novelty effect," a tendency for students to work harder and achieve more when a new novel medium is used. The novelty effect tapers off after a few months, once students become accustomed to the new medium. Although I don't debate the existence of this effect, it is probable that with at least some students, a semi-permanent preference for one medium over another might occur. This seems no more unreasonable that preferring one singer over another, or one brand of toothpaste over the next. Another interesting point is that this preference may have little to do with the actual effectiveness of the product.

Thus far I have been making a case based on logic and assumptions that from a cognitive point of view, there may be no difference in learning achievement but from an affective view, for any individual, there could be large differences in attitude and motivation that might interfere with learning of cognitive tasks. Through the laws of contiguity and association, we know that affect--positive or negative--gets paired with content. So not only might media alter one's motivation toward learning, and one's willingness to attend to a message, but medium may be adding a subliminal message to the content which actually *changes* the content.

What kind of statement is made if, for example, the president of a major international company gives his state-of-the-business address using hand drawn transparencies? Or worse, he writes on a blackboard. Might that give you a subliminal message that the company is doing poorly? Suppose he gave the same speech accompanied by 35mm film or high quality slides. Might you then think that the company was doing at least okay? Although the same symbol systems (written words) might be used, the overall message that a viewer receives is entirely different.

There are other activities and situations that just don't translate well to media--no matter how identical the symbol systems. McLuhan said in Understanding Media, "It is a truism among jazz performers that recorded jazz is as stale as yesterday's newspaper. Jazz is alive, like conversation..." As such, part of the enjoyment of jazz is the knowledge that it is spontaneous and being created on the spot, and you are privileged to be in the company of this "conversation" and creation. Sporting events are also an event where *being there* is half of the "learned" knowledge. You can watch the game on tv or read the box score for the cognitive parts of the game; the emotional, affective experience comes mainly from "being there." I once toured the house in Amsterdam where Anne Frank hid from the Nazis during World War II. Although I could probably see films of this house, and someone might even construct a simulated version of the house, it is not the same emotional experience as actually walking through the real environment. I'm not sure that this translates into a typical procedural training situation--but it does strongly suggest that in teaching affective content, media and reality factors make a definite difference and must be considered.

This is not to imply that media cannot move an audience; it is clear from the success of Hollywood all these years that media is indeed a powerful emotional medium. But, following the terms in this argument, films must use different symbol systems to produce the same emotional end. No doubt that a film of Anne Frank's house could move me, too--but it might take the addition of music, close-ups, different angles, and perhaps a story line to accomplish what a few moments of "reality" could induce. I'll come back to this point of different ways to evoke and cultivate cognitions, later in the paper.

COMMON USAGE AND POTENTIAL

Let's return to the research conclusion that if we hold all instructional strategies and symbol systems constant, then there will be no difference in cognitive learning regardless of the medium. Recall my earlier example of two experimental groups, one group reading a page of text and the other group reading that same text projected on a wall, and my conclusion that there would not be a difference in cognitive learning under these conditions. When I have mentioned such a study to "media people" the typical comment is that research of this type exploits totally inappropriate uses of the various media. That, in fact, no media producer would ever recommend that, for example, hundreds of pages of text be delivered via overheads or slides. The most appropriate way to deliver such content would, of course, be through books or other text based media. So while Clark's position is probably true in an experimental design research situation, where all variables could possibly be controlled for, in reality no one should ever use media in such inappropriate ways.

So, the question now is turning from **does** media make a difference to **can** media make a difference.

Each medium is a combination of attributes capable of carrying various combinations of different symbol systems. To the extent that media carry identical symbol systems relating to "critical" content (Salomon's term), then each medium should be interchangeable.

However, in a pragmatic sense, some media are capable of doing more. They have more attributes, or they can support more instructional strategies, such as allowing student input, personalized feedback, etc. Each medium, then may only be able to support specific instructional designs. For example, a more complex and versatile medium such as interactive video has the potential for serving and delivering many more instructional designs than a less sophisticated medium, for example a flip chart. What is interesting here is that Clark concludes that there are any number of ways to cultivate mental processing--and that there is not a one to one correspondence with any media attribute and a type of learning. He uses the terms "sufficient conditions" as opposed to "necessary conditions." Sufficient conditions can evoke certain learning, but are not necessary conditions, since any number of media attributes can evoke the same learning. This would make one assume that many different designs and approaches can achieve the same learning end.

However, Salomon, in 1978, said, "When critical information is coded differently in different media, learning outcomes cannot be the same because different mental operations are employed." So, I conclude that *only to the extent that similar mental operations can be stimulated, are media interchangeable*.

To tie this back to the reality versus media topic I previously mentioned, it may be that certain "live" events stimulate certain mental processes for a different *type* of learning. The awareness that an event is a real and unique experience may force different cognitive operations to occur; this may then foster different cognitive skills and learning outcomes.

The conclusion that media are interchangeable to the extent that they stimulate the same cognitive operations and skills is a powerful conclusion, and hints at some future directions for research. Adopting this perspective would hint that, along with media comparison research, even media attribute research is misleading--that we should be studying cognitive constructs that directly influence learning. This has been tried with mixed success with ATI research. However, it might be that the wrong constructs have been isolated. Aristotle said, "Break nature apart at her joints." It may be that some of our individual difference aptitudes have not been isolated in ways that maximize their predictive abilities, because they have been empirically conceived instead of theoretically derived, resulting in a shotgun approach (Jonassen, 1982).

I think that neurological theories of how the brain functions promise an immense contribution to the psychological study of how people learn. By directly exploring new cognitive constructs along with psychophysics, we might strengthen the bond between cognitive psychological research, neurological brain research, and instructional design theories. This would lead us to more accurate descriptions of the learning process, new constructs for research, and answers not to *whether* singers or songs are better, but *why*.

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Title:

Symposium: Interactive Video Symposium:
The Singer or the Song--
An Extension of Clark's Media
Research Discussion

Paper #5: A Review of the Research on
Interactive Video

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A Review of the Research on Interactive Video

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Introduction

Richard Clark's article, *Reconsidering Research on Learning from Media.* (1983), focused our attention on the effectiveness of media debate. Clark argued convincingly that media do not have a substantial impact on learning. This sentiment has been echoed by others including Clark and Angert (1980) who argue that "media researchers tend to operate within a vacuum and rarely acknowledge research investigations and results in parallel interests in other fields" (Moore, 1986, p. 190). Since the debate first emerged, one of our latest technologies, interactive video, has continued to grow in use. In considering the media comparison argument, it is useful to examine research on interactive video. The literature on interactive video can be classified according to four categories: reports of uses, descriptions of features and capabilities of interactive video, suggestions for design (Braden, 1986), and research and evaluation reports (Cushall, 1987). This paper focuses on research and evaluation reports.

In order to locate studies to be included in this review, a number of methods were employed. In addition to a search of ERIC documents and Psychological Abstracts from 1985 - 1989, working papers were solicited through faculty contact. The studies selected for inclusion in this paper meet the following criteria: (a) All reports included pertain to research or evaluation with interactive video. Research on computer-assisted instruction (CAI), although related, is not reviewed in this paper. (b) All studies included reported some form of data. The final selection of articles included both published and unpublished sources, with the intent of avoiding a publication bias.

Articles concerned with reports of uses or capabilities of interactive video, or with broad conclusions that failed to present data, were excluded from this paper. Readers interested in a broad review of interactive video are referred to excellent articles by Smith (1987) and Bijlstra (1988). In addition, interactive video research reported from 1980 - 1984 has been reviewed by Bosco (1987).

In their recent review of the literature on media, Clark and Sugrue (1988) analyze the trends and identify areas for future research. What are researchers studying with interactive video and where do we stand in terms of Clark's media comparison argument?

Clark and Sugrue (1988) have separated the literature into four basic areas. This paper examines interactive video studies according to the same categories: behavioral issues, cognitive issues, attitudinal issues, and economic issues. The first section reviews the studies that can be categorized as investigating variables in a behavioral paradigm. The next section details what variables have been investigated according to a cognitive perspective. The third section examines what has been learned from the investigation of variables in the affective domain.

Finally, the last section reviews studies which were concerned with economic issues. The tables appended to this paper include information on the principle investigator, subjects, content area, sample size, and variables explored for each of the articles or papers reviewed. This is similar in format to a review on interactive video reported by Bosco (1986).

Behavioral Issues

Clark and Sugrue propose that there has been a "paradigm shift" in media research from a behavioral orientation to a cognitive orientation. Is this evidenced in the research conducted with interactive video?

While there has been a shift, there are still a number of media comparison studies where interactive video is compared with some other type of medium (see Table I) such as computer based instruction or traditional lecture format. Interactive video has been compared to traditional computer based instruction, traditional lecture, non-interactive video, print based material, and laboratory exercises. Generally, instruction between two types of media are compared and effectiveness is defined as a score on a retention or achievement test. While many of these studies report the superiority of the interactive video medium over the comparison, close inspection verifies what Clark has said since he first presented his media comparison argument in 1983, the "active ingredient is usually some uncontrolled aspect of the instructional medium" (p.23, 1988). Rarely does one hear mention that the instructional method or content differences may account for the seeming superiority of interactive video.

For example, Peterson, et al (1988) asked whether videodisc-based programs help teachers achieve high levels of student mastery for large and diverse classes. They studied all of the fifth grade classes in Logan, Utah (n=11) on a level one application of interactive video and pre/post tested the students on embedded unit mastery tests. The posttest mastery scores were at the 70%. In addition, scores on the CTBS were compared to the previous year's CTBS test scores and general improvement was cited. In conclusion, the authors highlighted the ease of use of the videodisc and felt that its use contributed to the gains in the CTBS scores as compared to the previous year when only "traditional instruction" was offered. It seems that this study is lacking in validity in a number of ways. That is, how do the individual modules correlate with the CBTS test items? Is 70% mastery significantly better that what the mastery would be, given instruction in the traditional sense? The specific planning involved in the design of the level one application may have accounted for the variation in the test scores. Also, with small sample sizes which are typical of the interactive video studies reviewed, findings are not generalizable.

When one is examining the effects of different media, everything except the media compared must be the same, including instructional methods employed and content. While content generally is held constant in these media comparison studies, the instructional methods employed are not. Malouf et al (1986) tried to control instructional methods in a study comparing interactive videotape and workbook instruction of on-the-job skills for mildly handicapped teenagers. In order to match the two media as much as possible, each of the instructional activities in the videotape had a parallel activity in the workbook. Also, a single instructor delivered both treatments. While the videotape treatment was found to be superior, Malouf acknowledges the confounding effect of novelty due to the brevity of the treatment.

I would like to suggest that there are reasons that the instructional methods employed are not held constant. Often, the media comparison study examines already prepared lessons, or at best, one prepared lesson and one lesson specifically designed for research purposes. If we were not so quick to utilize existing discs, we might be more careful in our design of instructional methods for the treatments.

Often, and I have experienced this myself, one is presented with an opportunity to "repurpose" a disc for the purposes of research. Now, one might know that a number of examples need to be presented for the learner to fully grasp the content, however, if there are just three pieces of video footage on the disc appropriate for examples, one compromises knowledge about instructional strategies for the purpose of designing and conducting the research study. It is difficult to teach a principle, for example, with only three examples. However, a "fact" level lesson might be constructed with just three examples--and there we have a "compromise" in terms of our research design. If we are going to repurpose discs for the purpose of research, we should at least use some of the guidelines that have been suggested in the literature (Allen, 1986).

Perhaps the continued existence of media comparison studies is not too surprising when one considers that many of these studies are commissioned by the producers of the interactive videodiscs or the hardware who are looking for justification that their method is "right." Do we really need to compare in order to justify? In many instances it seems that it would be more appropriate to evaluate with the purpose of optimizing one particular medium. This is especially true because media are often pre-selected. Fortunately, the recent research studies conducted with interactive video have shifted toward exploring cognitive variables.

Cognitive Issues

Another of Clark and Sugrue's categories is that of cognitive issues. In the studies examined for this paper, there is reference to these cognitive issues but there are rare accounts of studies which have been conducted in order to quantify or understand some of the cognitive issues. For example, can media activate mental skills? Clark and Sugrue (1988) suggest that "future media research would do well to ask not just whether particular skills are acquired but also, how else they could be developed, and under what instructional, contextual, and psychological conditions they can be made to transfer." p. 29. Many studies have examined interactivity, feedback, and practice. While these variables could be classified as elements of instructional strategies rather than cognitive variables, typically the researchers have been interested in the effects of these variables on information processing which results in learning. For example, does increasing the 'interactivity' enable learners to process information more effectively, and affect how much information is retained?

A few of these of studies will be described here. Additional studies are included in the table appended to this paper (see Table I). Results from a study conducted by Hannafin, Phillips, and Tripp (1986) suggest that the availability of orienting activity affects both the type and amount of learning. Students given an orienting activity performed best under reduced time while students who were not provided with orienting activities performed best with extended time. There were interactions between orienting activities and processing time, suggesting that neither element alone affects learning. This is an example of a study that uses interactive video as a research tool. One can imagine a similar study conducted without an interactive videodisc and replications of these results could be generalized to a variety of learning situations.

In addition to orienting activities, the influence of practice for different types of learning has been investigated and the results are not uniform. In an investigation conducted using interactive video (Hannafin & Colamaio, 1986), practice was found to be important for the learning of declarative knowledge and problem solving skills, but of little effect for procedural knowledge. A later study conducted by Hannafin, Phillips, and Tripp (1986) investigated the effects of practice and processing time on learning. Their subjects were 80 volunteer college students. The practice items consisted of two multiple choice questions (one fact, one application). The posttest consisted of 32, five part multiple choice questions. One-half of them (eight fact, eight application) were practiced during the lesson and the remaining 16 items were new items. Practice resulted in favorable results only for the *facts* where test scores more than doubled the scores for non-practiced items (90% correct to 44%). However, test items at the application level were unaffected by practice.

One concern about these types of studies is whether or not they employ an adequate lesson format. The National Gallery of Art Tour has been adapted for the purposes of many of these studies (Hannafin, Phillips, and Tripp,1986; Hannafin & Colamaio, 1986; Jonassen,1987; Phillips, Hannafin, and Tripp, 1988). One wonders whether there are even sufficient numbers of examples and practice items present in these sequences of instruction, since the lessons are adapted from the existing tour. If the practice is simply rehearsal, then it is not surprising that the results showed practice to be effective for facts only, and not application exercises. This finding was also consistent with the earlier Hannafin & Colamaio (1986) study. If we accept the conclusions as given, the insertion of interactions in a lesson in the form of practice might not be relevant for the application level of learning performance, as this study demonstrated. However, this is in contradiction to most of the research on Component Display Theory (Merrill & Tennyson, 1977).

While some features of interactive video may be desirable for reasons other than learning effectiveness (i.e. attitudinal impact), the Hannafin and Colamaio (1986) study suggests that there may be limits to the effects of the interactions (in this case, practice). In terms of interactive video, this could mean that maximizing the capabilities of branching has little effect on learning. If these results were analyzed from a cost effectiveness point of view, many interactions would be unnecessary, and a waste of time. Of course, "practice" needs to be investigated more before such conclusions are drawn and interactive video as a research tool might be extremely helpful in this regard; however, the typical treatment would have to be revised radically.

A related study (Phillips, Hannafin, and Tripp, 1988) looked at practice and orienting activities on learning from interactive video. Seventy-two college students were randomly assigned to an orienting group and to one of three practice groups: No practice, Limited practice, or Elaborate practice. The lesson included both fact and application level learning of concepts in art. Students were measured on a posttest which consisted of 16 new and 16 repeated items for facts and applications taught during lesson. The means between the three groups were only found to be significant on the *repeated items*. There was not a significant difference between the different types of practice on the test items which were not included in the lesson. The orientation activities themselves did not contribute to learning as measured in this study.

This study warrants special consideration. It is not surprising that there was a significant effect of elaborate practice on the retention of the repeated items. The authors were trying to measure the effects of practice on two different performance levels: fact and application, however, the inclusion of so many repeated items reduces the experiment to a measure of pure recall. In order to test the effect of practice on application level learning, the lesson should be redesigned to include *new instances* at the test level.

I suggest that we advance our design of the lessons that we employ when investigating interactive video. Some of the features of interactive video would be especially helpful in the investigation of instruction at the principle or procedural level; however, it would entail additional design time and possibly, the creation of discs for the specific purposes of research.

Jonassen (1987) investigated the effect of practice on prototype development in a concept lesson in art history, utilizing the National Gallery of Art disc. Thirty college students participated in the study which measured (a) prototype only, (b) prototype and practice, and (c) prototype, elaboration and practice. The *prototype only* treatment presented the name of the style of art, plus three examples. The *prototype and practice* presentation was the same as the prototype only treatment, except that there were ten additional practice items and knowledge of results were provided to the learner. The *prototype and elaboration and practice* presentation was identical with the previous treatment except that it included an imaging strategy. Students were asked to close their eyes and imagine three characteristics of that type of painting and type their answers into the computer. This required the most elaborate practice (or in this case, "active processing") by the learner. The results showed that the prototype only group differed significantly from the other two groups on the posttest scores. However, there was not any difference between the *prototype and practice* and *prototype, elaboration and practice* groups.

It is difficult to determine whether or not the subjects performed the mental rehearsal strategy and to what extent they did. If in fact they did, and if the results could be replicated with a larger sample size, this study might provide evidence that additional practice in the form of mental rehearsal can be unnecessary for concept level learning. However, a study which examined principle or procedural learning might determine that mental imaging is important in far transfer for these levels of learning.

Basically, we are making progress in the pursuit of investigating cognitive issues with interactive video as a research tool. Our weakness seems to be in the actual lesson design of the discs employed to investigate the various variables. As studies improve in this regard, we should be able to investigate learner differences and processing variables. In addition, the features of CBIV would enable us to examine research questions concerning procedural learning, principle learning, generic skills, and instructional strategies.

Affective Issues

Motivation theory answers not only, "Did I like it" but whether the task is enjoyable, what skills are required to learn from the task, and do I have the skills I need to learn from the task? These questions refer to not only whether a learner has a particular preference for a type of medium but also to the amount of effort that will have to be invested in order to learn from a particular task. The research in this specific area is sparse. However, many of the studies in the literature report some measure of preference such as 'the learners preferred the interactive video over traditional lecture' but this is usually a secondary measure whereas achievement is of primary concern. Clark and Sugrue (1988) urge researchers to measure engagement, levels of effort, perceived demand characteristics, and self efficacy.

Have any of these variables been studied with regards to interactive video? Not yet. While there have been reports related to values and attitudes, these are confounded because the intent of the study is usually to measure achievement. One recently reported study (Bosco & Wagner, 1988) assessed the attitude of auto workers toward interactive video as compared to classroom instruction with video tape. All workers received instruction in *both* formats and since both formats were new to the workers, the researchers felt that this would control for the Hawthorne Effect. Often, studies examining interactive video ask the subjects to report their preference to something that the subjects reflect back upon whereas this study investigated attitudes after *all* of the subjects experienced *both* treatments. The content area was instruction on the handling of hazardous materials. When workers reported on their attitudes toward interactive video as compared to the classroom and videotape instruction received in the treatment, they responded more favorably to interactive video. Thus, if one is in a situation where either type of training is available, this evaluation study suggests that workers prefer interactive video.

I include here a related study that might provide a future direction for research on media attributes and attitudes. A study conducted by Simonson, et al (1987) suggests that attitudes can be modified by using media to deliver messages, and that some types of media may be more effective than others in modifying attitudes. While the Simonson and his colleagues compared motion pictures and slide tapes, this might be an area for further investigation and one that could be researched using interactive video as a tool. This type of study moves away from the media comparison format of the past. If everything else is held constant, it might be that *motion* is an important consideration when providing visual images that lead to attitude change. If it were determined that one needs to get as close to realism as possible when designing instruction for attitude change, then interactive video might be the most appropriate choice when *mediated* instruction is desired.

Economics and Cost-effectiveness

Clark's media argument was criticized by Petovitch and Tennyson (1985), who pointed out that while some media may not be more effective than others in terms of learning, they might be more cost effective. Cost effectiveness is an important consideration because it is a variable that can contribute to the types of decisions many clients need to make when considering mediated instruction. However, results from economic studies will not provide insights into instructional theory. Still, they are an area for needed research.

There have only been indirect measures of variables that relate to cost-effectiveness issues. Learning acquisition rate was measured by Schaffer and Hannafin (1986) in a study that examined four video treatments which differed in amounts of interactivity. The four treatments were: linear video only, video with embedded questions, video with questions and feedback, and fully interactive video (video, embedded questions, feedback, and remediation through branching). Schaffer and Hannafin (1986) computed the amount of recall versus instructional time and called this ratio, *acquisition rate*. The linear video treatment had the highest *acquisition rate* score. The authors concluded that the most efficient use of time versus learning is the non-interactive linear video. However, the highest recall scores resulted from the fully interactive treatment. This study did not determine whether the increase in recall could be due to the increased length of instructional time. However, this study did demonstrate that for instructional circumstances requiring a great deal of recall, interactivity is well suited. Perhaps the most important question is not whether interactivity enhances learning but whether it does so *sufficiently* to warrant the increased instructional time, and whether in view of this time/cost consideration, it is a feasible medium

Finally, a number of articles (Smith and Dunn, 1987 and Peterson, et al. 1988) cite productivity gains due to the use of CBIV. Teachers report feeling less pressure and increased teacher-student interactions as a result of being freed from the more 'mundane tasks' of instruction.

The reader is referred to Levin (1987) and Levin, Glass and Meister (1985) for examples of the type of cost effectiveness studies that might be conducted, examining interactive video. Levin (1987) examined the cost-effectiveness of CAI, peer tutoring, reduced class size, and increased instructional time (number of days in school). CAI was found to be more cost effective that increasing instructional time or decreasing class size. Levin suggests that the time and effort needed to obtain a given level of learning efficiency will decline as the technology of learning resources improves. Students will "wish" to allocate more time to learning activities as their efficiency in producing learning rises relative to their efficiency in the production of learning activities. This is an area of research which could have direct implications for media selection decisions.

Conclusions

The analysis in this paper might leave the reader feeling that there is little to argue for the effectiveness of interactive video and that we haven't made much progress since Clark first presented his "mere vehicles" argument. In terms of interactive video, I agree with Clark and suggest that we are asking the wrong questions. While many of the reports included in this paper and the appended tables conclude with a statement about the effectiveness of interactive video, increasing numbers are reporting data relating to instructional variables. There is much to warrant the use of interactive video as a research tool. Specifically, its ability to combine video, audio, text, and motion, as well as its branching capabilities suggest that interactive video can be extremely useful for presenting and collecting data in a controlled way. We MUST re-orient ourselves toward conducting research on instructional strategies or affective variables that lead to formulating generalizable theory. In addition, an increased focus on the evaluation of interactive video discs and their uses would enable us to optimize the medium for particular situations, types of content, and types of learners. As Heinich (1984) as argued, the main purpose of media research is to improve rather than prove media"!

If we are oriented to this end, it is likely that the media comparison studies which attempt to link interactive video with specific learning gains will disappear completely. I will be happy if in ten years, when reviewing this body of research literature, I find no mention of interactive video until I reach the methods section of an article. There, perhaps in the fine print, will be a phrase such as, "interactive video was used to present the treatments and record the data."

This suggestion, that interactive video be used as a research tool, is not new (see, for example, Grabowski and Pearson, 1988) however, it has been underutilized. It is much easier to construct experiments using existing videodiscs. I have yet to read about a videodisc that was *specifically* constructed for the purpose of research. Yes, there are many discs constructed for particular courses via IV that have formative evaluation built in to the development process. Many of these evaluations have taken the form of quasi-experimental studies and some of the results have been reviewed in this paper and the appended tables. However, the results are intended to provide information specific to that particular program, not to generalizable theory about instructional design.

What can be done about this? Imagine the generic research disc that Jonnasen (1984) first described- one that had a host of instructional treatments, presentation forms, events of learning, generic skills. Such a disc might take a long time to develop and for the one shot treatment would certainly be inappropriate. However, once developed, a number of studies could be conducted with a host of samples. The lessons employed in the treatments would be designed in the "ideal", according to instructional design principles, not according to the need for a quick instructional treatment to crank out some results. It has been difficult to evaluate the actual results of some of the studies reported simply because the format of the lesson is not fully described in the report. Is it a concept lesson, principle, etc? Is recall being measured again? Are we not beyond recall in our knowledge of prior research? This review of the literature on interactive video research demonstrates that while we have continued to conduct media comparison studies, we are beginning to research variables which might have more generalizable findings. The promise lies in using interactive video as a research tool. In addition, we need to conduct evaluation studies (see Reeves, 1986 for suggested models) on the medium itself, in order to optimize its features and capabilities.

Principle Investigator	Subjects	Subject Matter	n	Independent Variables	Dependent Variables	Results
Bosco (1988)	General Motors workers	hazardous materials	209	• level III interactive video disc • videotape	• achievement on posttest • opinion survey • user preference instrument to measure attitude	• subjects had higher achievement with IV • subjects tended to prefer IV but subjects exhibited positive attitudes towards both methods
Branck (1987)	Veterinary Students	heart auscultation	87	• videodisc & lecture • lecture only	• performance on practical exam	• video group more positive about learning • quality of videodisc rated good • no significant difference between the groups on the practical exam • video group began to listen only and not attend to video
Carter (1985)	mildly handicapped teenagers	budgeting	26	• brief feedback • extended feedback	• acquisition of concepts	• no significant difference in performance • interactive videodisc group exhibited less negative reaction to content
Dalton, D.W. (1986)	junior high	general shop safety rules	134	• video only • CAI only • interactive video	• performance • attitude	• CAI most effective • IV produced improvements in learner attitudes compared to CAI and video • attitude effects interacted differed across prior achievement level

Principle Investigator	Subjects	Subject Matter	n	Independent Variables	Dependent Variables	Results
Grover (1986)	adult	language & sociocultural infirmation	64	• interactive video • linear video	• content acquired • attitude changes • self reported behavior changes	• no significant differences between the two groups in terms of achievement and perceived difficulty
Hannafin (1986)	college	art	80	• achievement on posttest	• achievement on posttest	• practice found to be effective at the fact level; no effect for applications level
Ho (1986)	college & graduate	installing computer interface boards		• computer controlled review • learner controlled review • no review • objectives • no objectives • verbal info, concepts, rules	• achievement on posttest	• Both computer and learner controlled review found to have a signifcant effect on posttest scores. No difference between learner and computer controlled conditions • Learner controlled review significant for concepts only • Multivariate analysis did not produce significant differences for objectives
Jonassen (1987)	college	art	30	• prototype only • prototype & practice • prototype, elaboration, practice	• achievement on posttest	• sample size too small for broad conclusions

Principle Investigator	Subjects	Subject Matter	n	Independent Variables	Dependent Variables	Results
Lyness A.L. (1985)	nursing students	CPR	100	• Conventional instruction • Interactive video instruction	• Skill • Knowledge	• no significant differences between traditional CPR and interactive video • interactive video superior for obstructed airways
Malouf (1986)	high school learning disabled	on the job social skills	48	• interactive videotape • workbook • no treatment	• score on criterion reference test	• Interactive videotpe found to be superior to workbook instruction on identical objectives
Phillips (1988)	College	Art	72	• no practice • limited practice • elaborate practice	• retention	• Practice found to be effective at the fact level for repeated items • No significant difference found for practice on unencountered items
Smith (1986)	College	Chemistry	103	• IV lesson only • traditional lab • IV lesson & lab	• grade on lab report • performance on quiz	• IV and IV + lab group scored higher than traditional lab on quiz • iv lab scores were higher than traditional lab reports

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Title:

The Effect of Graphic Format and Cognitive Style on the Recall of Quantitative Data

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The Effect of Graphic Format and Cognitive Style on the Recall of Quantitative Data

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The Effect of Graphic Format on the Interpretation of Quantitative Data

Introduction

The power provided by computer graphics systems has greatly facilitated the production of professional quality graphic materials. The versatility provided by the software has made it possible to present numerical information in a multitude of chart formats. Most software packages allow the users to readily display the same data in a variety of different formats by a few simple keystrokes. However, educators and instructional designers still lack the empirical evidence to assist them in determining the "right" type of graphics to use in a given learning situation.

Washburne (1927) investigated the effects of tabular, textual, and graphic arrangements on recall. This study tested recall of specific amounts, as well as static and dynamic comparisons and rank ordering. Watson and Driver (1983) found that three dimensional graphic plots did not result in greater recall of information than did tabular presentation data. Benbasat and Dexter (1986) concluded that tabular reports led to better decision making and graphical reports led to faster decision making when time constraints were low. However, a combined graphical-tabular report was found superior in terms of performance. Even though the use of graphics in instruction has generally been recommended in the literature (e.g., Miller, 1969; Shostack & Eddy, 1971; Takeuchi & Schmidt, 1980), there have not been extensive studies which investigated the effects of these formats on recall.

The general advantages of graphics in presentations have been delineated by Watson and Driver (1983). Some of these advantages include 1) the ability to stimulate the interest of the user, 2) to aid in grasping relationships, 3) to save time when viewing masses of data, 4) present at a glance a comprehensive view of the relationship between different categories of information, and 5) to assist in analytical thinking. However, there appears to be a lack of research that supports the above claims. Winn (1987, p. 192) stresses the importance of developing "lines of inquiry into the learning strategies studies use when working with graphic forms." It is important to discover how and what students are learning from graphics. Are some graphics more effective than others? Are some types of information better presented different in graphic forms? Designers and producers of visual materials must also be concerned with a number of considerations included the nature of the instructional task, the teaching and learning strategies to be employed, and the individual characteristics of the learner.

The term cognitive style has been employed to describe strategies or models of perceiving, organizing and processing stimuli. The cognitive style of field dependence has been singled out as having major implications in the use of visual materials. Field dependence is important because it involves perceptual and problem-solving abilities, structuring a stimulus field, breaking up or disembedding such a field, suppressing irrelevant information, and dealing with high information load, all of which are relevant in the interpretation of data in graphic format. More specifically, it is of interest if there is any correlation between the various graphic formats and those individuals who are classified as field-dependent or field-independent. Field dependent students may have difficulty processing complex visual information (i.e., as a graphic format) unless it is presented in such a way as to compensate for specific processing deficiencies related to field-dependence.

Research Questions

The purpose of this study was to determine the effect of graphic format on the interpretation of numerical data. The formats used in this study were bar, line, table, and line-table graph. The three types of quantitative interpretation that were tested were specific amounts, and static and dynamic comparisons. It was also of interest to determine whether cognitive style (FD/FI) correlated with the ability of the subjects to interpret information in any particular chart format.

Methodology

The subjects for this study were 96 undergraduate college students enrolled in professional education classes or introductory educational psychology classes within the College of Education. The subjects were given Group Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971). The scores range from 0-18 with the higher scores indicating tendency toward field dependence.

The subjects were randomly assigned to one of four treatments which presented fictitious data in graphic form to alleviate any effect of prior knowledge. The fictitious data dealt with various European merchants income during the middle ages. The four treatments presented the same data in the following formats: 1) bar graph, 2) line graph, 3) table and 4) line-table combination. During the testing phase subjects responded by giving numerical or verbal answers in three categories: specific amounts as well as static and dynamic comparisons of the data. Example questions for each category are presented below.

Specific Amount

What was the income of the silk merchants in the year 1100?

Static comparison

Which group of merchants had the highest income in the year 1350?

Dynamic comparison

Which group of merchants had the greatest increase in income between the years 1100 and 1200?

All subjects in all treatments answered the same questions (each in the above three categories) the order of which was randomly altered for each treatment. The subjects were given the fictitious narrative and then shown a graphic format of the quantitative data, e.g., line graph on 35mm slide. The subjects had seven seconds to respond to each question while looking at the treatment slide, e.g., line graph.

A two-way analysis of variance was used to test the various null hypothesis in which the independent variables are type of graphic and type of recall. The design was 3 x 2 factorial design based upon a mixed model which used a combination of between and within subjects methods (all subjects would respond to all types of questions) while viewing only one type of graph. The dependent variable was the interpretation of quantitative information. A correlation was conducted using the raw scores total and score on the (GEFT) (0-18) for each subject.

Results

The means of the raw scores are presented in Table 1 and the means of the scores as percent correct responses are presented in Table 2. A two dimensional (3x2) analysis of variance design was employed to test the research hypothesis. The summary table of the analysis of variance based upon the table of means (Table 1) is presented in Table 3. A total of 96 subjects were used in this analysis. The F ratio for type of graph ($F(3,92) = 4.71$, $p < .005$) was significant. The F ratio for type of question ($F(2,184) = 46.56$, $p < .0001$) was also significant. The $F(6,184) = .107$, $p > .05$) between type of graph and type of question was not significant. The correlation coefficient of scores on the GEFT and the scores on the three types of questions was as follows: amount = 0.078, static = 0.182, and dynamic = 0.381. Figure 1 is a graphical representation of the means of the percent scores as function of type of graph and type of question.

Discussion

The post-hoc analyses of comparisons of means showed that *Ss* viewing the line graph had lower scores than for the table treatment for all three types (amount, static, dynamic) questions. This is a predicted result for the amount questions because the subjects simply had to read the data from the table. However, since the static and dynamic questions required the *Ss* to do comparisons in a given year (static) and scan across years (dynamic), the poor performance of the line treatment was unexpected and merits additional experimental work.

Subjects viewing the bar graph did not differ from the line graph treatment for any types of questions, but had lower scores for the amount and static questions when compared to the table treatment. The bar graph scores did not differ from the table for dynamic questions. The relatively poor performance of the bar group on the static questions also merits additional work. Future studies of this type should increase the amount of data in the table and decrease the time of each trial. Both of these conditions would provide a better approximation to conditions in a classroom or business meeting.

This study partially confirmed the results of Benbasat and Dexter (1966) in that tabular reports were better than graphical formats, but did not find that combined

Table 1. Mean Raw Score as a Function of Type of Graph and Type of Question

Graph Type	Type of Question			Mean
	Amount	Static	Dynamic	
Line	12.67	12.83	10.63	12.04
Bar	12.83	12.96	11.58	12.46
Table	13.63	13.67	12.29	13.19
Line-Table	13.54	13.00	12.29	12.94
Mean	13.17	13.12	11.70	12.66

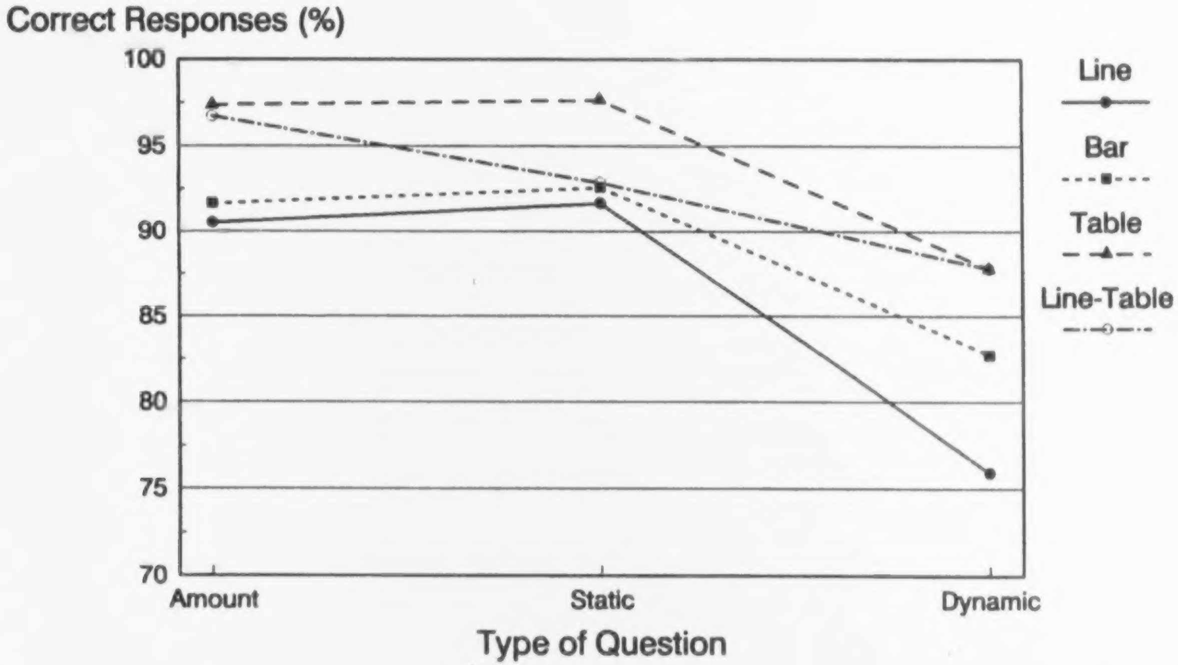
Table 2. Mean Percent Score as a Function of Type of Graph and Type of Question

Graph Type	Type of Question			Mean
	Amount	Static	Dynamic	
Line	90.50	91.64	75.93	86.00
Bar	91.64	92.57	82.71	89.00
Table	97.36	97.64	87.78	94.21
Line-Table	96.71	92.86	87.78	92.43
Mean	94.07	93.71	83.57	90.43

Table 3. Summary of Analysis of Variance

Source	df	SS	MS	F	p
Between subjects					
G (Type of Graph)	3	56.85	18.95	4.71	< 0.005
Subjects w. groups	92	369.81	4.02		
Within subjects					
Q (Type of Question)	2	133.34	66.67	46.56	< 0.001
G X Q	6	15.22	2.54	1.78	n.s.
Q X subjects w. groups	184	263.44	1.43		

Figure 1. Percentage Correct Responses as a Function of Chart Type and Type of Question



tabular and graphical (line-table) were superior to table in terms of performance. However, the Ss in Benbasat and Dexter (1966) did have much larger data sets to interpret which would favor the combined format.

This study did not produce much indication that there is a strong relationship between field dependent/independence and the scores on the different types of questions. However, it does not preclude the future investigation of cognitive style and the type of graphic presentation.

The preliminary nature of this study does not lend itself to conclusions which can be readily translated into specific recommendations for selecting graphic formats for business or educational environments. However, it does provide a basis for additional work which might lead to such practical applications.

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Title:

Applying Semiotic Theory to Educational Technology

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Applying semiotic theory to educational technology

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Abstract

When education (teaching and/or learning) is considered to be an art, then it seems obvious that the methods of artistic inquiry would be appropriate analysis techniques. Such analysis seems rare or non-existent in educational technology. Semiotics, the theory of signs, provides one such set of methodologies for examining text. This presentation will explore the products and processes of educational technology as text using a variety of semiotic critical methods.

Semiotics is often divided into syntactics, semantics and pragmatics. Semiotic criticism can be based on just one or two of these divisions or it can include all three. Syntactic criticism focuses on the structures of the work. These structures can be assessed simply in terms of the evolution of structural form (and the possibility of revolutionary change in form) or the forms can be evaluated in relation to the use of the work. Semantic criticism stresses meaning manifest in the work. While semantics are normally applied to textual materials, critics have also used semantics as a formal approach to visual literacy concepts. Pragmatics link antecedents (causes), features of the work, and results. Such inquiry can address unintended or unanticipated effects a work might have on its audience.

Introduction

THERE IS AN EXCITING DEBATE which appears to be just peaking within the field of educational technology. Our focus of research questions is broadening out. We are moving from questions of "how?" to questions of "why?" We are moving from a search for a single interpretation of reality and truth, towards multiple and simultaneous interpretations. We are moving from an acceptance of strictly scientific modes of inquiry towards an acceptance of a variety of critical alternatives.

Today's symposium attempts to recognize some of these alternative methodologies. Whether our individual focus is criticism and connoisseurship, or reader-response theory, or post-modernism or semiotics, our joint objective is to provide new ways of looking at old questions, and perhaps at new questions.

The keyword around which this paper will operate is **semiotics**, the study of signs. While the term has been traced back to 1641, referring specifically to "signs and symbols and the study of their use in conveying meaning (Barnhart, 1988, p. 982)," semiotics itself has only recently and rather quietly entered the vocabulary and the consciousness of educational technologists. Yet its import is reflected in the contemporary literature, albeit still almost unnoticed.

Look at only four of the the most recent examples. In the latest issue of Programmed Learning and Educational Technology from the United Kingdom, David Smith (1988) examines interactive media and instructional software from a semiotic viewpoint. "New ways of conceptualizing human interaction are evolving which are not predicted on hard 'engineering models. [One such is] a practical development of semiotic analysis" (p. 342).

In the US, the Educational Communications and Technology Journal (Korac, 1988) has recently featured a paper suggesting a semiotic analysis of audiovisual media. And another ECTJ paper titled "Good Guys and Bad Guys" (Cunningham, 1986) takes on Richard Clark's meta-analytic research. Noting that educational technologist's elusive goal is to "discover once and for all which method/medium is best, which is the good guy, and which is the bad guy.", Cunningham argues for a constructivist and semiotic approach to educational research, so that knowledge is seen as being constructed rather than discovered. Then, "if we come to understand the constructive nature of our knowledge, we can make more modest, context-dependent claims about 'the truth of the matter' and be less embarrassed when we are wrong. In other words, there are no good guys and bad guys, only guys"(p. 7).

A fourth example is a just released book by Marshall & Eric McLuhan (1988). Titled Laws of Media, the study presents four "laws", provides a structural analysis of selected media, and concludes with a suggestion for a focus on media poetics (that is, the systematic study of media as literature):

> As the information which constitutes the environment is perpetually in flux, so the need is not for fixed concepts, but rather for the ancient skill of reading that book, for navigating through an ever uncharted and unchartable milieu. Else we will have no more control of this technology and environment than we have of the wind and the tides. (p. 239)

The above examples should at the very least serve to point out that interest in semiotics is not an isolated one. It seems safe to suggest that semiotics is entering the vocabulary and the modes of inquiry of educational technologists. Yet what is semiotics? The term seems to be not well known and writers seem to run immediately into problems of definition. "Education is a field in which semiotics has had relatively little impact" (Cunningham, 1987).

What is semiotics?

Semiotics is the study of signs and sign systems of all kinds. It involves the production of signs, communication through signs; the systematic structuring of signs into codes; the social function of signs, and finally, the meaning of signs. The first important insight which semiotics provides is that signs and sign systems are arbitrary and culturally bound. The second important insight from semiotics, which follows the first, is that linguistic concepts can be used to analyze far more than merely linguistic texts, but all texts, where a text is anything to be read, in the broadest sense.

Robert Scholes(1982): "semiotics has in fact become the study of codes: the systems that enable human beings to perceive certain events or entities as signs bearing meaning...As an emerging field or discipline in liberal education, semiotics situates itself on the uneasy border between the humanities and the social sciences...As the study of codes and media, semiotics must take an interest in ideology, in socioeconomic structures, in psychoanalysis, in poetics and in the theory of discourse"(p ix-x). If semiotics is concerned with signs, then it is equally concerned with meaning. Ultimately, semiotics is the study of meaning, meaning systems, and the origination and generation of meaning. These meanings are grounded in text and discourse.

David Sless (1986): "Semiotics is above all an intellectual curiosity about the ways we represent our world to ourselves and each other" (p. 1).

"Semiotics studies messages and in order to study messages we have to read them. A reader is always a participant, never an observer" (p. 30).

Umberto Eco(1976): "Semiotics is concerned with everything that can be taken as a sign. A sign is everything which can be taken as significantly substituting for something else...semiotics is in principle the discipline studying everything which can be used in order to lie" (p. 7).

Where do semiotic studies fit within the educational technology endeavor?

Educational technology, most often described as a "systematic approach" to teaching and learning, is inevitably involved with communication, signs, codes, and meaning. Therefore, it would seem that semiotics should be a compatible and parallel field from which educational technology might benefit. There is a major tradition in education, ultimately overlapping with educational technology, into which a semiological approach seems especially appropriate, namely curriculum theory. It is this tradition which provides a potential coupling of educational technology and semiotics.

Schubert (1988), borrowing from Habermas(1971), identifies curriculum as operating within three alternative paradigms. The dominant curriculum paradigm is the "technical" (Habermas: empirical-analytic). A second paradigm for curriculum inquiry is the "situational interpretive" (Habermas: Historical-hermeneutic). The third paradigm is identified as "critical theoretic" (Habermas: critical theory). Aoki (1986) describes the focus of interest in each: In the technical or means-ends model, "interest is in the ethos of control as reflected in the values of efficiency, effectiveness, certainty and predictability. In the situational-interpretive or practical paradigm, interest focuses on "the meaning structure of intersubjective communication between and among people who dwell within a situation." In the critical-theoretic mode, interest is "emancipation from hidden assumptions or underlying human conditions."

This technical/practical/critical trichotomy is useful in locating what is taking place in educational praxis. Educational technology with a penchant for better task analysis techniques and more precise behavioral objectives, not to mention a concentration on the next new medium just around the corner, falls squarely within the technical orientation.

Within curriculum theory there is also a readily identified "practical" dimension of curriculum exemplified in the writings of Joseph Schwab (1973). Schwab's well known commonplaces are the teacher, the learner, the milieu, and the subject matter. "Defensible educational thought must take account of the four commonplaces of equal rank...None of these can be omitted without omitting a vital factor in educational thought and practice."

When one examines the AECT "official" definition of educational technology side by side with these four commonplaces, the similarity becomes apparent:

> Educational technology is a complex, integrated process involving people, procedures, ideas, devices, and organization for analyzing problems, and devising, implementing, evaluating, and managing solutions to those problems (AECT, 1977).

The juxtaposition of the two definitions is additionally significant, since it illustrates that educational technology is not locked into the technological paradigm, but indeed has apparently endorsed this second significant alternative paradigm. Such a positioning of educational technology shows that the discourse of the field is not as one-sided and single-minded as some would have us believe.

Semiotic, connoisseurship, and post-modern approaches fall within the third paradigm, the critical. Within this third paradigm "the object of the critic ... is to seek not the unity of the work, but the multiplicity and diversity of its possible meanings, its incompleteness, the omissions which it displays but cannot describe, and above all, its contradictions" (Belsey, 1980, p. 109). It has **not** normally been the concern of educational technology to focus on this domain. The role of the technologist is to implement someone else's objectives. As recent a text as Knirk and Gustafson (1986) is clear on this point: "Although an instructional technologist may have a voice in creating policy, he or she is primarily responsible for *implementing* policy decisions...If an instructional technologist questions the goals, an interpretation should be provided by a representative of the policy making body " (p. 33, emphasis mine). Such a statement clearly places educational technology as overlapping the technical and practical dimensions as identified above, but outside the critical dimension.

Yet today's symposium argues precisely in favour of adding this third paradigm to the discourse of educational technology.

Semiotic questions in educational technology

This section will identify some key semiotic concepts which appear to hold particular promise for educational technology. Time and space permit not much more than a mere listing of areas ripe for exploration.

1. **The concept of sign**. The nature of the interaction between signifier and signified (from Saussure), and the importance of semiosis and the interpretant (from Peirce) provide starting points for an examination of meaning of and within educational products.

2. **Structure of educational media as constructed "text"**. A variety of methodologies exist which have been used to explicate underlying structure in literature, poetry and film. Such techniques need to be applied to educational media and technology.
3. **The role of the reader**. Reader response theory extends semiotics by focusing on the newly re-discovered importance of the reader in the triadic relationship between the author, the text, and the reader.
4. **The Rhizome**. The rhizomatic (rhizome = tuber, plant root which is at once root, stem, bulb, connects all parts of the plant to all other parts) metaphor of Umberto Eco (1984) provides a useful extension and/or alternative to the cognitive view of learning.
5. **Syntagmatic and paradigmatic analyses**. Paradigmatic and syntagmatic analyses require the reader to examine the structure of texts in terms of its horizontal and vertical dimensions. Sophisticated insights into the nature of media, technology, and mass culture have resulted from such analyses in a variety of fields from literary criticism to sociology.

At this point it is appropriate to turn to an example which is illustrative how semiotics can inform the role of the instructional developer.

The case of the limp french fries.

A few years ago, I attended a convention on instructional development. I remember a session in which the speaker was talking about how she had identified a training problem and developed an appropriate solution. The problem area was restaurant management. A problem had developed in some of the restaurants which were producing "limp" french fries. This was diagnosed as a training problem. There were, as you can imagine, a variety of potential solutions. Perhaps the potatoes were not kept long enough in the fat. Perhaps they were too thick, so could not crisp properly. Perhaps they were allowed to "drip dry" too long; or perhaps it was not long enough. The ultimate cause is not important here. What is important is that a systematic, positivistic model allows one to identify the problem, examine alternative potential causes, and develop an appropriate solution. If it turns out that the solution is not the right one, we recycle. Eventually, through trial and error, through test and retest, through constant monitoring, the problem will be solved.

So where's the debate? I like limp french fries. In fact, where I come from, Winnipeg, Manitoba, where the winter wind chill temperature can exceed 40 below, the hot, thick, greasy, and yes, "limp" french fry, is the *only* french fry. A limp french fry means real potatoes were used, not the re-constituted kind. A limp french fry means freshly cut potatoes; not the kind you buy pre-cut, pre-packaged; pre-formed. A limp french fry implies only potato; no unnecessary and unhealthy additives to guarantee a false and unnatural crust. In short, the only french fry is a limp french fry.

There is more. If by chance, the french fries come out crisp (heaven forbid), we have a variety of ways to make them limp again. Americans add ketchup. Canadians add white vinegar. And in Winnipeg, an especially popular solution is to serve french fries with gravy. Then they have to be limp!

* * * * * * * *

What I have just presented you with is a rather simplistic example of **deconstruction**, usually credited to Jacques Derrida (1976). Deconstruction is intended to be an astute and careful reading of a text such that the apparent meaning breaks down, and reverses itself when subjected to close scrutiny. Deconstruction is at the heart of the post-modern enterprise. It is carrying the semiotic project to its limit.

Look what our analysis has done. By identifying a problem, we note a series of binary oppositions: limp/crisp; bad/good; unacceptable/acceptable. Second, we see that the concept "crisp" is unintentionally "valorized" as being the ultimate quality. Once we recognize that, we can reverse the valorization. The result is a displacement, and a re-ordering of values. The original meaning crumbles. (Interestingly, in this process, the new reading itself is equally susceptible to a deconstructionist reading,)

What are the implications for curriculum? What are the implications for educational technology? The basic questions of what to teach and why and how are increasingly subject to deconstructionist readings. Why? Because the " post-modern turn" no longer allows a complacent, linear view of how things work. The post-modern view is an all-at-once view, a discontinuous, intermittent view, a view commensurate with a multi-cultural society. The traditional subject is de-centered. And most important, we are allowed to question the very ground on which we stand. We are not only allowed, but encouraged to ask "Why?"

But I am getting ahead of myself. I have moved into the areas of post-semiotics, or post-structuralism, or post-modernism.

Let us return to the case of the limp french fries. Our purpose will be to unpack the text and to uncover the structural ambiguity which is inherent in the process of reading, interpretation and understanding. For educational technologists, such a task is paramount. Following the schema of Sless(1986), we begin by recalling the author - text - reader paradigm. In fact, there are two types of texts. The author/text is the text generated by and understood by the author. The reader/text is the text generated by the reader in his search to make sense of the author/text.

We can horizontally represent my role as reader of the story of the limp french fries as R1. This reader is directly linked to the instructional developer who authored the ID report. Let us call this individual A2. Schematically we have:

R1..................A2

However A2, before becoming and author, was a reader, which can be designated R2. It was this reader who noted and identified the problem of the "limp french fries, identifoed as P. Now we have

R1...........A2/R2...................P

Returning to the beginning of the scheme, we see a missing step. I am no longer a reader R1 of this story; but in telling it to you, I am an author. The current reader is you, R0:

R0..................A1	R1......................A2	R2......................P
This Presentation	Instructional Developer	Product

What we have produced is the first stage of a schematic representation of the story of the limp french fries as it moves from a variety of perspectives and interpretations. To summarize:
R0 is you as reader of this presentation, here and now,
A1 represents me as author of this presentation,
R1 represents me as reader of the "limp french fries" story,
A2 represents the instructional developer as author,
R2 represents the instructional developer as reader of the situation, and
P represents the situation, as read by the instructional developer.

Of course, one might increase the level of complexity, as well as the length of the horizontal displacment, but that is unnecessary at this stage. The purpose of such an exercise is to highlight the constructed nature of reality leading to a clearer understanding of the social interactions involved. In addition, the technique attempts to identify the layers through which the reader/author dichotomy has moved.

One additional comment will serve to round off this analysis. First, the model brings out an intriguing comparison with our penchant to model the human mind on the computer. There is, interestingly, a computer version of this activity which I have just described. Whenever one wishes to copy a file onto a backup disc, one goes through a process in which the computer reads the file, then copies or writes that file onto the new disc. While this is happening, the computer screen presents a message which typically says "reading" during the first phase, then "writing" during the copying phase. These terms, reading/writing alternative until the entire file is copied.

The situation is analogous to the reader/author interaction described above. However the difference is significant. In the computer model, the computer "reads" everything, literally, then "writes" everything. What makes humans special is that we read selectively as we are simultaneously influenced by a host of environmental and social factors; then we write, also selectively. Semiotics brings out clearly the very human characteristics and the constructed characteristics of message and meaning analysis.

Conclusion

In this paper, I have tried to highlight some dimensions of applying semiotic techniques to educational technology. Semiotics produces techniques for reading texts. As educational technology becomes more sophisticated, we need to familiarize ourselves with the complex relation of text to author to reader. As educational technologists we are all three.

Yet our road to improve communications is a thorny one. Douglas Adams said it with sarcasm in The Hitchhiker's Guide to the Galaxy , but his warning is not to be taken lightly.

> ...if you stick a Babel fish in your ear you can instantly understand anything said to you in any form of language...[T]he poor Babel fish, by effectively removing all barriers to communication between different races and cultures, has caused more and bloodier wars than anything else in the history of creation. (p. 50)

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Title:

Perceptions of International Students Toward the use of Educational Media in Their Home Countries

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PERCEPTIONS OF INTERNATIONAL STUDENTS TOWARD THE USE OF EDUCATIONAL MEDIA IN THEIR HOME COUNTRIES

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PERCEPTIONS OF INTERNATIONAL STUDENTS TOWARD THE USE OF EDUCATIONAL MEDIA IN THEIR HOME COUNTRIES

INTRODUCTION

The purpose of this study was to examine the perceptions of international students toward the use of educational media in their home countries.

Every year thousands of international students come to the United States for higher education and advanced training. The majority of these students, upon their return, are expected to hold leadership positions in education, business & industry, and government. As leaders they are expected to play the roles of planners, advisors, decision makers, change agents, and administrators. Also these people are likely to be involved in the process of transfer of technology, or adoption-diffusion process of innovations in their home countries.

Claudine Michel (1987) has also highlighted the importance of international students in the process of transfer of technology or adoption-diffusion process of innovations in their home countries. There are three groups of people involved in such processes. The First group includes members of a foreign nation like educators and business representatives who try to convince the decision-makers of a country to adopt the new technology. The Second group comprises those individuals in a country who are assigned the task of solving educational problems. The third group is the well familiar group of international students in various U.S. colleges and universities. It is the members of the third group that comes into short or long-term contact with the most recent educational media when they enter European of American universities. In some cases they become not only acquainted with the new educational media, but also adequately experienced in using some of them. When these international students return home, they take with them not only their increeased knowledge, skills, and experience, but also their perceptions and attitudes toward educational media. They go home to assume positions in teaching, government, educational administration, and business & industry.

Rogers and Shoemakers (1971) have listed a large number of studies indicating that favorable perceptions are positively related with adoption-diffusion of innovations. Therefore, the perception of international students toward the use of educational media in their home countries is one of the critical factors that needs to be considered by those interested in introducing new educational technology, or in expansion of markets for various educational media in developing countries.

RESEARCH QUESTIONS

Based on the foregoing facts, this study was designed to answer the following questions:

(1) What is the nature (positive or negative) of international students' general perception toward the use of educational media in their home countries?

(2) What is the level of international students' general perception toward the use of educational media in their home countries ?

(3) What is the level of international students' perceptions toward the use of educational media in relation to educational institutions, business & industry, and government ?

(4) Do the general as well as specific perceptions of international students toward the use of educational media vary in terms of levels of their academic programs, experience with media, information about media, and annual per capita incomes ?

DEFINITIONS AND DESCRIPTIONS OF TERMS

For clarity and better understanding, definitions and descriptions of some basic terms and expressions used in the study are given below:

International Students: The term international students refers to students from developing countries enrolled in different programs in Fall 1989 at Michigan State University.

Home Countries: They refer to countries to which international students will return after completion of their education and training in U.S.A. for permanent settlement.

Educational Media: This term refers to those media which are used in teaching, learning, and training environments as instructional aids. For example, pictures, films, slides, audio and video tapes, computers, interactive video and the like. It does not include printed books and blackboards which are the basic educational media used in developing countries.

Use of Educational Media: It refers to the perceived practice of educational media in teaching, learning, training, and information processing environments.

Nature of Perception: This term means whether the perception of international students is positive (favorable) or negative (unfavorable).

Levels of Perception: It refers to high, medium, and low levels of respondents' perception.

Levels of Academic Programs: This term refers to undergraduate or graduate status of the respondents enrolled in Fall 1989 at Michigan State University.

Levels of Experience: This term points out to the degree of actual interactions of the respondents with various educational media as teaching, learning, or training tools.

Levels of Information: It refers to the respondents degree of simple knowledge of various educational media, e.g., what are they ? What do they do ? What they are used for ? etc.

Annual Per Capita Income: This expression means the annual per capita income of the people in respondents' home countries as reported in the 1988 Almanac.

METHODOLOGY

POPULATION AND SAMPLE

The study used a cross-sectional survey method. The population for this study consisted of all international students enrolled in Fall 1989 at Mighigan State University. These international students included students only from developing countries of Asia, Africa, Latin America and Caribbean. A total of 29 countries were represented.

By using random sampling technique, a sample of 350 was drawn for this study. Out of this 350 international students, only 208 returned the completed questionnaires. The rate of return was 62%, which was considered adequate for the data analysis.

DATA COLLECTION

The data were collected through a structured questionnaire with a 5-point Likert scale; which was designed, developed and tested for this study. The questionnaires were mailed to the respondents with cover letters, and two weeks were allowed for the return of the completed questionnaires. Those who did not return the questionnaires within a two-week period, were once more requested through telephone calls to return the completed questionnaires within a week's time. These efforts helped collect 208 completed questionnaires which formed the basis for the data analysis.

DATA ANALYSIS

To analyze the data frequencies, percentages, means and analysis of variance were used. The data were analyzed by the computer using SPSSX.

Means were computed to find the levels of general perception of the respondents, and also to compare the levels of perceptions toward the use of educational media in education, business & industry, and government. To determine the levels of perceptions mean scores were collasped as follows: means over 4 to 5 = high level; means 3 to 4 = medium level: and means below 3 = low level.

Analysis of variance was used to examine the variations in perceptions due to academic programs, experience, information, and annual per capita incomes in respondents' home countries. Scheffe post hoc test was also run to find which of the two parts of a group were significantly different. Academic programs were indicated by undergraduate and graduate, and the levels of experience and information were expressed as high, medium and low based on their respective mean scores. Mean scores were collapsed as follows: Mean scores of 1.25 to 2.99 = low level; 3 to 4 = medium level; and 4.01 to 5 = high level. The high (above $10,000), medium ($1000 to $10,000), and low (below $1000) levels of annual per capita incomes were determined on the basis of annual per capita incomes reported in the 1988 Almanac for respondents' home countries. The questionnaire used a 5-point Likert scale and the weights were assigned as follows: Strongly Agree = 5; Agree = 4; Neutral = 3; Disagree = 2; and Strongly Disagree = 1. For item numbers 6, 7, 18 and 19 weights were reversed.

VARIABLES

For this study, the independent variables were respondents' academic programs, experience, information and annual per capita incomes. The dependent variable was respondents' perceived use of educational media in their home countries.

FINDINGS OF THE STUDY

The findings of the study are presented below:

NATURE AND LEVELS OF PERCEPTIONS

The findings of the study indicate that the general perceptions of the respondents toward the use of educational media was positive in nature and were expressed at a high level ($\bar{x}$=4.09).

The data were further analyzed to see the levels of respondents' perceptions toward the use of educational media in education, business & industry, and government. Respondents indicated a higher level of positive perceptions ($\bar{x}$=4.15) toward the use of educational media in business & industry, followed by government ($\bar{x}$=4.14), and education ($\bar{x}$=4.04). Table 1 contains the data.

VARIATIONS IN PERCEPTIONS

A significant difference (F value of 3.96 at .050 significance level) in respondents' general perception was indicated in terms of levels of their annual per capita incomes. Scheffe test showed that respondents with high and low levels of annual per capita incomes differed significantly. However, no significant differences were noticed in terms of levels of academic programs, experience and information. Table 2 presents the data.

Results also indicate that respondents' specific perceptions in relation to education, business & industry, and government differed significantly. Differences were found in respondents' specific perceptions in relation to education by levels of information (F value of 3.86 at .050 significance level), and annual per capita income (F value of 4.50 at .050 significance level); in relation to business & industry by levels of experience (F value of 3.43 at .050 significance level) only; and in relation to government by levels of experience (F value of 4.53 at .050 significance level) and levels of annual per capita income (F value of 3.21 at .050 significance level).

MINOR FINDINGS

Out of 208 respondents, 39 were undergraduates and 169 were graduate students. With regard to levels of experience, only 3 indicated a high level of experience with educational media, 48 respondents reported medium level of experience, whereas 157 respondents stated that they had a low level of experience with educational media.

In respect of levels of information about educational media, 15 respondents said that they had a high level of information about educational media, 149 respondents reported their information level at medium level, and 44 respondents stated they had a low level of information about educational media.

With regard to levels of annual per capita incomes, the results showed that 13 respondents belonged to high level of annual per capita income countries, 60 belonged to medium level, and 135 belonged to low level of annual per capita income countries.

Other minor findings indicate that the respondents were from 29 developing countries. They came from 15 Asian countries, 10 African, and 4 from Latin American and Caribbean countries.

INTERPRETATIONS AND CONCLUSIONS

The high level of respondents' general perceptions toward the use of educational media shows a favorable perception of international students toward educational media in their home

Table 1

Rank Order of Perceptions in Relation to Educational Institutions, Business & Industry and Government in terms of Mean Scores

Categories	Rank Order	Number	Mean	SD
Business & Industry	1	208	4.154	.337
Government	2	208	4.146	.339
Educational Institutions	3	208	4.037	.314

Table 2
One-Way Analysis of Variance For General Perceptions in Terms of Selected Independent Variables

Variables	No.	Mean	SD	F Ratio	F Prob.
PROGRAM LEVELS					
Undergraduates	39	4.15	.219	2.707	.101
Graduates	169	4.07	.281		
EXPERIENCE LEVELS					
High	3	3.84	.381	2.068	.129
Medium	48	4.05	.347		
Low	157	4.11	.241		
INFORMATION LEVELS					
High	15	4.01	.356	2.874	.058
Medium	149	4.12	.257		
Low	44	4.02	.279		
PER CAPITA INCOME LEVELS					
High	13	4.26	.151	3.956	.020*
Medium	60	4.12	.303		
Low	135	4.06	.260	Scheffe:High > Low	

* Significant at .050 level.

countries. The reason for this high favorable perception may be due to respondents' experience with and information about educational media. This high level of favorable perceptions of international students can be profitably manipulated in favor of efforts directed toward introducing new educational technology or achieving greater use of educational media in developing countries.

Respondents expressed a higher level of perceived use of media in business & industry, closely followed by government in their home countries. The use of educational media in educational institutions was perceived at a lower level by the respondents. This may be explained, in most cases, by the limited resources available to educational institutions for change and innovations. Business & industry, and government, therefore, seem to be more potential targets for introduction of new educational technology or for expansion of the use of educational media in developing countries.

Respondents from high annual per capita income countries differed significantly in their perceptions from respondents belonging to low annual per capita income countries. This may be due to big difference that exists in the annual per capita incomes of respondents belonging to these two groups of countries. Countries like Kuwait and Saudi Arabia with the annual per capita incomes of $18,180 and $11,500 respectively, have greater capacity to introduce new educational technology or to expand the use of educational media in their schools, business and government than countries like Nepal with an annual per capita income of $ 170, or Ethiopia with $ 110 only. This leads us to conclude that countries with high annual per capita incomes are better targets for introduction of new educational technology, or for expansion of the use of educational media than countries with low annual per capita incomes.

The study is limited in its scope and coverage. It is confined to international students at Michigan State University. As a result, its findings can not be generalized. Also the findings of this study are based on perceptual data. The very nature of perceptions being fluid makes the problem of measurement elusive.

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Title:

Effects of Successful Female Role Models on Young Women's Attitudes Toward Traditionally Male Careers

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Effects of Successful Female Role Models
on Young Women's Attitudes Toward Traditionally Male Careers

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Introduction

Despite their increasing numbers in the work force, women continue to be concentrated in only 20 of the 440 occupational classifications listed by the Department of Labor. Almost 80 percent of working women remain in low-paying, low-skilled jobs with limited opportunities for advancement. In 1983, only 3.4 percent of the engineers and 25.6 percent of the scientists were women (U.S. Bureau of the Census, 1986).

Cultural sex stereotyping is a major factor in guiding women in their career choices. Shinar (1975) asserts that sexual stereotypes of occupations are clearly defined and agreed upon by both females and males. Both groups express greater interest in careers traditional for their own sex (Gregg & Dobson, 1980). In her review of studies of occupational stereotypes, Gottfredson (1981) found that people's perceptions of occupations were similar regardless of their sex, age, social class, educational level, or ethnic group. Compatibility of a career with one's self-concept is influenced by the sextype of the job.

A great deal of human behavior is developed through modeling. New patterns of behavior can be acquired through vicarious experience -- observing others perform successfully (Bandura, 1977). Investigators have used positive role models to change student attitudes toward careers not traditional for their sex. Greene, Sullivan, and Beyard-Tyler (1982) and Savenye (1983) provided subjects with exposure in written or slide form to role models successful in nontraditional careers. Results of the two studies showed significant positive change in student attitudes about the appropriateness of careers not tradtional for each sex. Angrist and Almquist (1975) found that women who chose nontraditional careers were twice as likely as women who chose traditional careers to state that occupational role models were the major factor influencing their choice.

Exposure to sex-equitable materials results in more flexible attitudes about sex roles. Schau and Scott (1984) reached that conclusion from their review of the literature. Ashby and Wittmaier (1978) found that fourth-grade girls who heard stories about women in nontraditional occupations rated traditionally male jobs and personal characteristics as more appropriate for females than did girls who heard stories about women in traditional occupations.

Active participation in a treatment group can have a persuasive impact. In their review of research, Fleming and Levie (1978) found that subjects who participated in role-playing or in group discussions about an issue demonstrated greater attitude changes than those who were simply given information.

Belief in one's ability to succeed is a major factor in career choice. Females reported significantly greater confidence in their ability to perform traditionally female jobs than traditionally male jobs (Betz & Hackett, 1981). McMahan (1982) found that college females had lower expectations for success in cognitive tasks in general than did college males and that they rated their performance to be lower than did males. Junior- and senior-high females (Rosen & Aneshensel, 1978) reported lower expectations with regard to their academic achievement than did males. Fennema and Sherman (1978) report that as early as the sixth grade, girls express less confidence than boys in their ability to do mathematics. In high school they perceive mathematics as being less useful to them. Differences between females and males in motivation and achievement in science are small, but consistent, and favor males (Steinkamp & Maehr, 1984).

Two career areas that offer challenge, high pay, prestige, and opportunity for professional growth are science and engineering. Females from elementary school through high school believe that science is a career for themselves as well as for boys (Steinkamp & Maehr, 1984). However, Ware, Steckler, and Leserman (1985) found that women at the college level report less enjoyment of their science courses than males and abandon their interest in a science career at greater rates than men. Among explanations offered for women's failure to pursue science and mathematics careers are traditional sex-role behavior and their perceptions of their abilities.

The purpose of this study was to examine the effects on young women of reading about nontraditional role models in the sciences and engineering, and discussing with a trained instructor various aspects of participating in science and engineering careers. The dependent variables studied were (1) appropriateness of the careers for both women and men, (2) expressed interest in the careers, and (3) subjects' belief in their ability to succeed in the careers. There were two treatment conditions (experimental vs. control) and two evaluation conditions (pretest vs. posttest). To test for a possible generalization effect, subjects' attitudes were assessed both on careers included in the treatment and on a sample of careers not included in the treatment. A Career Survey developed from instruments devised by Greene et al. (1982) and Betz and Hackett (1981) was used to measure student attitude. It was predicted that attitudes of the experimental group would become more positive toward the careers included in the treatment. It was further expected that the positive attitude change would generalize to the second set of science and engineering careers not presented during the experimental instruction.

Method

Subjects

Subjects for the study were 153 tenth-, eleventh-, and twelfth-grade female students enrolled in advanced, elective science classes (chemistry, qualitative and organic chemistry, physics, and advanced biology) at a suburban high school in the Phoenix metropolitan area. There were 73 students in the experimental group and 80 in the control group. All female students in advanced, elective classes were included except for those few in one class that met at a time when no other subjects were available. Subjects had completed from two to seven semesters of study in both mathematics and science. Responses to a question regarding careers being considered indicated that nearly all planned to pursue a college undergraduate degree and many planned advanced study.

Materials

Experimental materials prepared for the study consisted of an instructor guide and the following instructional materials: (1) overhead transparencies presenting facts on women in the world of work, (2) descriptions averaging 747 words in length portraying the career and lifestyle of four women in traditionally male jobs, and (3) discussion questions.

Careers selected for the study were professional jobs that require a background in science and/or mathematics and in which at least 70 percent of those currently employed are male. To appeal to a broad range of interests, two each were selected from engineering, physical sciences, life sciences, and health diagnosing practices. One of the two careers from each occupational group, or a total of four in all, was presented to the subjects in the experimental group. The careers are listed below.

Occupational Area	Careers Presented	Careers Not Presented
engineering	industrial engineer	biomedical engineer
physical sciences	petroleum geologist	food chemist
life sciences	forester	fish and wildlife biologist
health diagnosing practices	optometrist	veterinarian

The job descriptions for the careers presented information obtained in interviews conducted by the author with women in traditionally male jobs. Standard content in job descriptions in the Occupational Outlook Handbook (U.S. Bureau of Labor Statistics, 1984) provided the basis for the interview questions: nature of the work, working conditions, educational and training requirements, earnings and other rewards, and employment outlook. Other information in the career descriptions included the role model's reason(s) for her career choice, her lifestyle, and advice to high school students regarding career search.

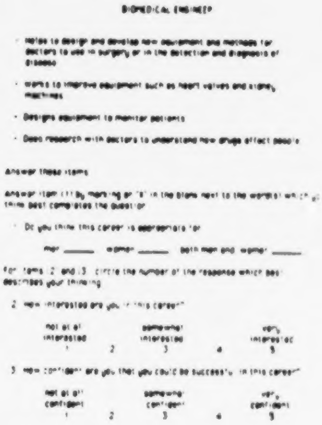
The instructor guide followed accepted instructional design practices as described by Gagne and Briggs (1979). It provided the instructor with the objectives of the program, an overview of the program to present to the subjects, a motivating activity (facts about women in the world of work), guidance in the presentation of career information, and discussion questions and suggestions on how to relate the information to the target audience and to enhance generalization of the information.

The overview and motivating activity included data on numbers of working women, average years in the work force, percentages of working women by marital status and with children, increasing percentages of women in traditionally male careers, and weekly salaries in relation to the percentage of women in the job. Statistical information was obtained from the U.S. Bureau of the Census (1984a, 1984b) and the U.S. Department of Labor (1984).

The discussion questions were designed with two purposes in mind. The first was to relate skills already possessed by the students to those important in the careers. The second was to encourage discussion of solutions to potential problems encountered in entering the career.

Criterion Measure

The Career Survey was constructed to measure subjects' beliefs about the appropriateness of the careers for both women and men, their interest, and their confidence that they could succeed in the eight careers. Each of the eight pages listed a single career with a brief description of its major responsibilities and three questions to be answered. The descriptions were included so that both experimental and control groups would share common knowledge about the basic job responsibilities. All eight careers were included in the pre- and posttests for both the experimental and control groups. A sample set of items for one occupation, biomedical engineer, from the Career Survey follows. The three attitude questions were the same for all eight occupations.



BIOMEDICAL ENGINEER

- Helps to design and develop new equipment and methods for doctors to use in surgery or in the detection and diagnosis of disease
- Works to improve equipment such as heart valves and kidney machines
- Designs equipment to monitor patients
- Does research with doctors to understand how drugs affect people

Answer these items

Answer item (1) by marking an "X" in the blank next to the word(s) which you think best completes the question

1. Do you think this career is appropriate for

men _____ women _____ both men and women _____

For items (2) and (3) circle the number of the response which best describes your thinking

2. How interested are you in this career?

not at all interested		somewhat interested		very interested
1	2	3	4	5

3. How confident are you that you could be successful in this career?

not at all confident		somewhat confident		very confident
1	2	3	4	5

Procedures

Teachers of the science classes included in the study administered the pretest to their students (both female and male) three weeks prior to the treatment. Males were included in order to not draw attention to the intervention. Only the responses of the female students were analyzed. A female graduate student with several years' experience in high school teaching was trained as the experimenter.

The study was conducted during regularly scheduled classes on two consecutive days. Female students were blocked by class and then randomly assigned to the treatment or control group.

The experimental treatment consisted of the following:

Day 1: (1) Presentation of statistics on women at work.
(2) Reading of two career descriptions, with each followed by the discussion of questions relating to personal skills required in performing the job and to solving problems on the job.

Day 2: (1) Reading and discussion of the remaining two career descriptions.
(2) Discussion of general questions: the effect of sexual stereotypes on thinking about a career; some of the barriers and/or problems in entering a career typically followed by men; and how to overcome or solve the above.
(3) Posttest.

Subjects in the control group (and male students) were administered the posttest during their regular class time on Day 2 of the intervention with the experimental group.

Design and Data Analysis

A 2 (experimental vs. control) x 2 (pretest vs. posttest) x 8 (careers) factorial design with three dependent variables was used. A multivariate analysis of variance (MANOVA) was performed to determine whether females' attitudes toward traditionally male careers changed as a result of treatment, and whether those attitudes generalized to careers not included in the treatment. Univariate analysis of variance (ANOVA) data for each dependent variable are reported when the overall MANOVA and the univariate effects are both at or beyond the .05 level of probability.

Results

The means and standard deviations of scores obtained for each of the three dependent variables for each of the eight jobs by treatment condition are shown in Table 1. Item responses for appropriateness were obtained on a three-point scale with "men" as (1), "women" as (2), and "both men and women" as (3). The goal of the study entailed assessing the degree of change from a stereotypic male-oriented view of the careers. As such, the change from a male orientation to either a female or androgynous view represents the construct under study. Item responses for interest and confidence were obtained on a five-point scale ranging from "not at all" (1) to "very" (5) for both interest and confidence.

The data were submitted to a 2 (treatment conditions) x 2 (testing conditions) x 8 (careers) mixed multivariate analysis of variance (MANOVA) procedure. This analysis assesses significant differences due to the between-groups factor (treatment condition), the two within-groups factors (testing sessions and job), and the interaction of these on effects.

Multivariate and univariate analysis of variance results are presented in Table 2. Results are reported for main effects, two-way interactions, and the three-way interaction effects.

Main Effects

Multivariate analysis of variance for group revealed nonsignificant differences between the experimental and control groups. Consequently, univariate analyses were not explored. The two group pretests were similar.

Both MANOVA and ANOVA results showed significant differences due to testing session. Multivariate analysis revealed an overall difference (Λ = .34219, F (3, 127) = 81.378, p < .001. Univariate analyses revealed differences on all three dependent variables: F (1, 129) = 182.737, p < .001 for appropriateness; F (1, 129) = 116.621, p < .001 for interest; and F (1, 129) = 14.476, p < .001 for confidence. Subjects typically scored higher on the posttest than on the pretest. This is a common result, probably due to familiarity with the instrument as a consequence of the pretest session.

Multivariate analysis for job showed significant differences as well, (Λ = .73972), F (21, 2588) = 13.641, p < .001. Results from univariate analyses were also significant: for appropriateness, F (7, 903) = 26.606, p < .001; for interest, F (7, 903) = 15.567, p < .001; and for confidence,

$F(7, 903) = 28.007$, $p < .001$. This indicates some careers were perceived as more appealing than others.

Two-way Interactions

The multivariate analysis of variance performed on the group by test interaction revealed a significant difference showing that the experimental group experienced greater positive change than the control group, $(\Lambda = .93413)$, $F(3, 127) = 2.985$, $p < .05$. Univariate analyses for the dependent variables appropriateness and interest showed no significant differences ($p > .05$), but the univariate analysis for confidence was significant, $F(1, 129) = 5.557$, $p < .05$. While both groups showed gain from pretest to posttest, the experimental group had a significantly larger gain in confidence in being successful in the jobs.

No significant difference was found in the multivariate analysis of the group by job interaction. Both groups held similar views of the jobs being tested.

The test by job interaction revealed significance in both the multivariate and univariate cases. The multivariate analysis yielded a large difference, $(\Lambda = .84521)$, $F(21, 2588) = 7.432$, $p < .001$. Univariate analyses resulted in $F(7, 903) = 12.234$, $p < .001$ for appropriateness; $F(7, 903) = 11.254$, $p < .001$ for interest; and $F(7, 903) = 6.837$, $p < .001$ for confidence. This indicates that both groups perceived the careers more positively on the posttest.

Three-way Interaction

The group by test by job MANOVA result showed a nonsignificant interaction. Consequently, univariate analyses were not explored. Changes within the experimental and control groups were found to be unrelated to job.

Discussion

In this study, tenth-, eleventh-, and twelfth-grade female students from advanced, elective science courses read about and discussed successful women in traditionally male careers. It was predicted that their attitudes toward careers with regard to (1) appropriateness for both women and men, (2) interest, and (3) confidence in their ability to be successful would become more positive. It was also expected that those positive attitudes would generalize to careers that were not presented. Results showed that for the experimental group there was a significant positive change in confidence across all eight careers surveyed on the posttest, both those that had been presented in the intervention and those that had not.

The generalization effect did take place. There were no significant differences for the variables appropriateness and interest.

The intervention was not effective in changing young women's attitudes with regard to the appropriateness of the careers for both women and men. However, the data suggest that there was a ceiling effect that had not been observed in earlier, related research. The highest score possible on this measure, 3.000, was evidenced on 10 of the 32 items. This indicates that the instrument was not sensitive enough to adequately measure the full range of student attitudes. The high scores throughout raise the question of the efficacy of intervening with this relatively sophisticated population. The young women in the study may have benefitted from societal changes of the past few years.

Though interest in the careers did increase somewhat, the difference between the groups was not significant. Treatments of one to five class periods in length have not demonstrated effectiveness in increasing students' interest in careers not traditional for their sex (Brooks, Holahan, & Galligan, 1985; Savenye, 1985). Apparently, more powerful and longer-lasting interventions are required. Perhaps it is necessary to help students determine their interests and skills and relate these to career opportunities and job responsibilities.

Appropriateness, interest, and confidence are clearly related, but the nature and extent of the relationship are not understood. Perhaps greater increase in interest follows successful experience and increase in confidence. Higher self-efficacy expectations may broaden or reopen occupational areas that previously had been judged inappropriate. Ginzberg, Ginsburg, Azelrad, and Herma (1951) reported that adolescent males had great difficulty identifying their interests and aptitudes. They hoped to discover their interests and abilities through college or work experience.

The significant positive change in confidence among subjects in the experimental group supports Bandura's (1977) theory that vicarious experience (here, reading about a successful role model) increases self-efficacy. Angrist and Almquist (1975) and Auster and Auster (1981) report on the importance of exposure to, and support of, role models in young women's nontraditonal career choices. The generalization effect suggests that the present intervention can be useful with a variety of jobs.

There are three important factors to consider in future studies. One is to work with a younger, less sophisticated group that will have no ceiling effect. Additionally, a younger group may be more persuasible (Fleming & Levie, 1978). Another factor is to work with intact classes in which students have had time to become comfortable with each other. It may be necessary to provide time to develop rapport between the experimenter and the group and among members of the group if it is desired that the subjects participate in a discussion. A third factor is to understand what qualities and/or values females attribute to particular jobs and what job characteristics are important to them. Careers can be analyzed and presented in terms of the attributes and responsibilities that may appeal to females.

Perhaps it is true, as Gottfredson (1981) suggests, that by adolescence, occupational choices have been limited to what is perceived as appropriate for one's own sex. A variety of activities -- including hands-on experience, observing and talking with role models, site visits, assessment of interests and abilities, and a relating of skills and valuesto job responsibilities -- may be required on an ongoing basis to promote positive and stable attitudes toward the full range of occupational opportunities available today.

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Table 1
Descriptive Statistics Regarding Attitudes Toward Nontraditional Careers by Treatment Condition

	Experimental (N=63)				Control (N=68)			
	Pretest		Posttest		Pretest		Posttest	
Careers	M	SD	M	SD	M	SD	M	SD
industrial engineer								
appropriateness	2.714	.705	3.000	.000	2.588	.815	2.868	.486
interest	1.571	.856	1.905	1.043	1.765	.948	2.088	1.116
confidence	2.222	1.170	2.762	1.341	2.500	1.153	2.794	1.264
food chemist								
appropriateness	3.000	.000	3.000	.000	2.956	.270	2.926	.315
interest	1.714	.941	1.762	.979	2.132	1.064	2.132	1.105
confidence	2.254	1.092	2.683	1.242	2.750	1.084	2.912	1.278
petroleum geologist								
appropriateness	2.810	.592	2.968	.252	2.838	.536	2.750	.655
interest	1.651	.970	1.730	1.019	1.868	1.050	1.779	.928
confidence	2.222	1.128	2.524	1.216	2.515	1.240	2.618	1.222
fish & wildlife biologist								
appropriateness	3.000	.000	3.000	.000	3.000	.000	2.912	.376
interest	2.365	1.182	2.571	1.353	2.485	1.275	2.794	1.166
confidence	3.000	1.218	3.328	1.388	3.074	1.176	2.618	1.176

Note. Item responses for appropriateness were obtained on a 3-point scale with "men" as (1), "women" as (2), and "both men and women" as (3). Item responses for interest and confidence were obtained on a 5-point scale ranging from "not at all" (1) to "very" (5) interested and confident.

Table 1 (continued)

	Experimental (N=63)				Control (N=68)			
	Pretest		Posttest		Pretest		Posttest	
Careers	M	SD	M	SD	M	SD	M	SD
optometrist								
appropriateness	2.984	.126	3.000	.000	2.971	.243	2.971	.170
interest	2.397	1.225	2.651	1.285	2.235	1.148	2.721	1.118
confidence	2.904	1.254	3.270	1.139	3.118	1.166	3.368	1.145
biomedical engineer								
appropriateness	2.921	.373	3.000	.000	2.824	.571	2.882	.441
interest	2.175	1.302	2.206	1.138	2.235	1.198	2.662	1.288
confidence	2.413	1.291	2.794	1.246	2.618	1.339	3.176	1.257
forester								
appropriateness	2.873	.492	2.968	.252	2.765	.649	2.824	.571
interest	1.698	.891	2.143	1.148	1.647	.927	2.088	1.156
confidence	2.413	1.253	2.889	1.271	2.574	1.213	2.809	1.385
veterinarian								
appropriateness	3.000	.000	3.000	.000	2.956	.270	2.971	.170
interest	2.857	1.318	3.063	1.243	2.588	1.318	3.044	1.251
confidence	3.127	1.350	3.381	1.268	3.162	1.288	3.456	1.321

Table 2
Multivariate and Univariate ANOVA Source Table for Appropriateness, Interest, and Confidence

		Multivariate			Univariate		
Source of Variance	Wilk's Lambda	df	F	p	df	F	p
main effects							
group	.98853	3, 127	.491	ns			
appropriateness					1, 129	.016	ns
interest					1, 129	1.055	ns
confidence					1, 129	.611	ns
test	.34219	3, 127	81.378	.001			
appropriateness					1, 129	182.737	.001
interest					1, 129	116.621	.001
confidence					1, 129	14.476	.001
career	.73972	21, 2588	13.641	.001			
appropriateness					7, 903	26.606	.001
interest					7, 903	15.567	.001
confidence					7, 903	28.007	.001

Table 2 (continued)

		Multivariate			Univariate		
Source of Variance	Wilk's Lambda	df	F	p	df	F	p
two-way interactions							
group by test	.93413	3, 127	2.985	.05			
appropriateness					1, 129	.966	ns
interest					1, 129	.067	ns
confidence					1, 129	5.557	.05
group by career	.97096	21, 2588	1.271	ns			
appropriateness					7, 903	1.490	ns
interest					7, 903	.608	ns
confidence					7, 903	1.196	ns
test by career	.84521	21, 2588	7.432	.001			
appropriateness					7, 903	12.243	.001
interest					7, 903	11.254	.001
confidence					7, 903	6.837	.001
three-way interaction							
group by test by career	.98188	21, 2588	.787	ns			
appropriateness					7, 903	1.627	ns
interest					7, 903	.934	ns
confidence					7, 903	.508	ns

Title:

Teachers and Technology: An Appropriate Model to Link Research with Practice

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Teachers and Technology:
An Appropriate Model to Link Research with Practice

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Teachers and Technology:

An Appropriate Model to Link Research with Practice

This paper grows out of an increasing frustration with the direction taken by research, development, and practice in the field of educational technology over the past dozen years. That frustration has roots that are complex, but the tension itself may be simply expressed: although educational technology was in its origins intimately connected with the work of teachers and schools, in recent years the focus of the field has increasingly shifted toward applications in business, industry, and higher education. Those research studies, development and implementation projects, and evaluation reports that do concern themselves with K-12 settings may take a diffusion-and-adoption approach to teachers' use of hardware, consider a particular medium's effectiveness as an instructional tool to reach particular objectives, or examine the applicability of some specific instructional development (ID) model to the organization and delivery of curricular material in one or more subject domains.

Those educational technologists who have surveyed the scene in the public schools (e.g., Heinich, 1984, 1985) often assert that the only sensible approach is to encourage rapid and comprehensive acceptance of a strict ID approach to the design, implementation, and evaluation of instruction in the schools. Heinich particularly decries the continued "craft" approach to their work among teachers, and sets this in opposition to a "technological" approach. The field of educational technology, he suggests, has more to do with technology than it does with education. Others (e.g., Branson, 1987) are less specific in their criticism, but intimate that the rationale for the existence of schools (almost always discussed in terms of knowledge production and transfer of information to the next generation) has been so seriously impacted by technology and other changes that their presence as a social institution past the year 2000 must be questioned.

This is what I find troubling, for schools as a social institution collectively have other (and, many would argue, more important) purposes than the transmission of information to their charges. Teachers, too, are more than classroom-based implementors of instructional strategies. In fact, there has been during the past years much discussion about the radical reform of schooling, and about teachers' key role in that process, discussion which educational technologists (with a very few notable exceptions) do not seem to have acknowledged, much less joined. If schools and teachers will continue to exist in some form, then, and if the largely antithetical positions described here are in fact representative of teachers' and technologists' views, how should educational technologists concerned with public education proceed?

This paper first reviews educational technology and teaching, considering each field from two perspectives--that of the technologist, and that of the teacher. It then characterizes the current state of the movement to radically restructure education, and suggests how educational technologists might join in and contribute to that discussion. It concludes with suggestions, drawn from current research on teaching and on educational practice, for new initiatives that educational technologists might take in four areas: (1) the preparation of models for teaching-with-technology; (2) the design of intelligent software; (3) the creation of technologically-based tools to support teachers' professional work and development; and (4) the improvement of research about technology in education.

Educational Technology

The technologist's vision. I do not need to recite here the recent history of the field of educational technology. Others have adequately chronicled the gradual transition from a focus on devices to a concern with process, the shift to an emphasis on the definition of systematic instructional models and procedures, and the gradual growth of interest in cognitive as well as behavioral principles as conceptual underpinning for the field (Reiser, 1987; Saettler, 1968).

The result of this activity has been the creation of instructional design and development, a combination of elegant instructional models (design) and practical procedures (development) for the delivery of instruction. No one can really deny at this point the popularity and practical appeal of ID as an approach--note the rapid growth of DID within AECT, the concomitant growth of other similar associations and groups (NSPI, ASTD, etc.), and the success of ID as an approach in business and industry (evidenced by the expenditure by businesses of an amount annually roughly equivalent to all the costs of higher education in this country).

The point is that activities of educational technologists, defined now largely in terms of instructional design and development, are increasingly distanced from the work of ordinary teachers in the public schools. Richey (1986), for example, opens her book with the following:

> Planning instructional programs and materials has been separated from the jobs of those who actually deliver the instruction in a growing number of situations.... The dichotomy between instruction and instructional design ... is ... influenced by different theoretical orientations and different practice histories (p. 2).

The fact of this division is, however, something about which I feel that we as a field must be concerned.

Schools, then, have been notably and curiously removed from the concerns of technologists. Those who have looked at schools seem to feel that, if only teachers would use ID approaches, classroom practice would be vastly improved. Students would become motivated, instruction would become clear and logical, student achievement would increase, teachers would be freed from the drudgery of routine tasks, and classroom activities would become more varied (e.g., Reigeluth, 1987). The appearance recently of a special thematic issue of JID on "ID and the Public Schools" (Salisbury, 1987) testifies to the scarcity of this approach in general.

The vision has been remarkably consistent. The problem has been that teachers have been slow to respond, either to the blandishments of those who have encouraged teachers to use technology-as-hardware, or to the suggestions of those who have maintained that ID might provide solutions to educational problems. As Goodlad (1984) and Cuban (1984) have pointed out, most classroom practice today looks remarkably like classroom practice 80 or 100 years ago. The expectations and hopes of technologists have changed; reality, in the main, has not.

The teacher's vision. Yet classroom teachers do turn to educational technology, if often for reasons other than those technologists might hope. For most teachers, "educational technology" still implies hardware and associated software, not the process approach of ID. Showing films and tapes, for example, offers relief from the routine of classroom interaction, and many teachers choose consciously to do this. Cuban (1986) quotes a teacher, "Sometimes the motor needs to idle before it is put back into gear"

(p. 69). Films and tapes may also provide a "trigger," a stimulus in conjunction with work toward "expressive outcomes" of learning that are purposely not defined by the teacher in advance (Eisner, 1979). Programs and software used in such an exploratory fashion may also open an avenue for experiencing the world in ways otherwise impossible (Copeland, 1984, 1986).

Working with the tools of technology may also provide for students opportunities for personal empowerment and personal liberation not otherwise easily found in classrooms. Ellsworth (1987), for example, described the ways in which the production of videotapes could enhance students' awareness of social problems and their sense of empowerment to act in regard to those problems. And Schwartz (1987) used video with underprivileged youngsters to engage them in academic activities that otherwise would have been unlikely to succeed. Most teachers probably see such approaches as more essential to their roles as teachers and to the learning of their students than a strictly defined application of instructional design and development. When teachers do confront the technologist's vision of precisely engineered materials, controlled experiences, and measured outcomes, they may react not with enthusiasm but with rejection (Nunan, 1983).

Only a few researchers have consciously attempted to define teachers uses of and ideas about technology. Cuban's (1986) book is one notable exception; another is the work of David Cohen (1987) at Michigan. Both argue that the teacher's world is substantially limited by powerful social and administrative pressures to teach in particular ways. Even if teachers did want to think about educational technology as something larger than machines and software, they have remarkably little opportunity to do so. Teachers are not provided with or taught how to use more helpful alternative models during teacher training.

Teaching

The technologist's vision. The metaphors used in descriptions of educational technology tell us much about technologists' views of the instructors with whom they work. Hlynka and Nelson (1985) identified three dominant metaphors for educational technology in the literature of the field: "tools," "engineering," and "systemic" (in a broad artistic and aesthetic sense which they likened to musical performance). Unfortunately, many technologists unconsciously adopt either the "tools" or "engineering" metaphors. For these, teaching might be defined as the administration of instructional materials or programs in such a way as to effect learning. While lip service has been paid to the possibility of addressing all types of purposes of schooling--the affective as well as the cognitive, the long-term as well as the short, the "higher-order" and critical/synthetic/judgmental as well as the factual and objective--in fact most studies in the field focus on the latter part of each of these relations.

In fact, the way that many educational technologists think and write about teaching suggests that the teacher's role is something to be refined and shaped by principles of instructional design: inconsistencies are to be smoothed out, digressions eliminated, predictability developed. The principal product of the educational technologist's work--a carefully prepared set of instructional procedures--is designed in such a way as to minimize the teacher's contribution. Indeed, many educational technologists would posit that an important aspect of their work is to eliminate the need to have a human instructor present.

Educational technologists have also been seen as "change agents," encouragers of new instructional practices and procedures. Visions of educational change are thus also important for us to examine in seeking to understand technologists' views of teaching. Earlier experience has cautioned those educational technologists most eager to redefine the teacher's role in terms of dependency on engineered design. Attempts in the 1950s and 1960s to penetrate the education market with teaching machines with names such as "techno-teacher" and "auto-tutor" proved notably unsuccessful, and the intensely designed (and thus "teacher-proof") curricula of the 1960s (PSSC Physics, MACOS, etc.) either failed to win acceptance, or were nominally accepted but modified in practice to such an extent that they became indistinguishable from the preceding classroom routine.

These problems led educational technologists to conclude that "teacher adoption" of new instructional strategies was a topic worthy of study. Early ideas about how to change schools were dominated by "rational-empirical" assumptions (Chin & Benne, 1969): showing people improved practices should lead them to change what they do. Typologies were constructed of "innovators," "early adopters," and so on (Rogers, 1962).

Most educational technologists have accepted the assumptions of the rational-empirical model. They also made other assumptions—that teachers find technology (qua hardware and software) easy to use, that technology (qua process) readily fits into the context of classroom activities, and that instruction should become a rational science. Studies based on this model of change examined teachers not only as users of educational technology but also as potential barriers to its use. Teachers' attitudes toward computers, their willingness to change, the extent of their acceptance of technology have all been considered. "Resistance to change" has been a central topic for discussion, and infusion of technology-as-hardware and technology-as-process have been taken as a given for the improvement of teaching.

The teacher's vision. Defining what teachers think their work consists of turns out not to be an easy task. Several studies of classroom life have portrayed teachers as earnest, but harried. The job of managing 25 or 30 young people in a confined space for many hours each day explains why "classroom management" is such a perennial favorite in-service workshop topic among teachers. That teaching is work (and thus not always the glamorous "life of the mind" or pleasant "being with children" that some pre-service teachers hope), that it is hard (elementary schools experience a turnover of more than 7% of their teachers each year; secondary schools, more than 6%; Center, 1987), and that it provides few rewards other than the psychic are facts about their careers that most teachers recognize only after they have been teaching for a year or two.

Nevertheless, teachers do usually create for themselves a classroom world that reflects both their teaching style and their preferred ways of working with students. Characteristics of that world have been limned in several studies over the past several years (Lortie, 1975; Dreeben, 1973; Jackson, 1986): teachers often feel isolated from their peers, but find sustenance in the routine of classroom life; they resent intrusion from outside, and find most administrative requirements to be "red tape" that they would rather do without; their interest in constructing curriculum themselves or developing alternative instructional materials (other than a traditional textbook) is severely constrained by a lack of time for anything other than the most basic classroom maintenance, leading in turn to an almost overwhelming demand for "the practical" (Doyle & Ponder, 1977/78) in approaches, materials, or hardware.

In addition to these general features of classroom life, recent studies on the professional knowledge base of teaching, teachers' thought processes, and the school setting have illustrated the demands on attention and effort that a teacher typically must cope with in daily work (e.g., Feiman-Nemser & Floden, 1986). Research on teacher thinking has pointed out the dilemmas and uncertainty that teachers routinely face (Clark, 1988; Peterson, 1988). Inquiry into the nature of teachers' professional knowledge has suggested that the links between teaching practices and particular curriculum content may be more subject-specific than previously thought (e.g., Shulman, 1987). And teachers have been urged to become more professional not by adopting a routinistic approach to problem solving, but by becoming more "reflective" (Schon, 1987) and by celebrating, not rejecting, the image of their work as a craft (Greene, 1984). In all these cases, emerging evidence highlights aspects of the teacher's work that are ambiguous, uncertain, difficult to cast into the molds educational technologists have wrought.

Educational Reform and the Educational Technologist

The past six years have witnessed a growing interest in general educational reform. Perceived declines in academic standards led to a number of critical reports in the early 1980s (e.g., National, 1983; Boyer, 1983; Education Commission, 1983). Student abilities in mathematics and science became objects of special concern (National Science Board, 1983; College Board, 1983). Among the other problems dealt with in this phase of the reform movement were: the role schools play in the national economy; the effectiveness of schools in providing students with a core set of cultural assumptions and values; and the need to accommodate through schooling diverse ethnic and linguistic groups in the larger national culture. The feasibility of introducing to schools new technology (especially computers) for instruction and management also became a concern at this stage of the reform effort.

This "first wave" of school reform has now been overtaken by a further, and possibly more significant, "second wave" of reform. The new emphasis is on the need for significant restructuring of the organization and practices of schools as preconditions for any further significant change in education (AFT, 1987-88; Eisner, 1988; Elmore & McLaughlin, 1988). The role of the teacher in defining what happens in schools, how students are to be taught (and how teachers themselves are to be selected, educated, and certified), are the critical questions for second-wave reformers. Joseph McDonald (1988) described this second wave as the search for "the teacher's voice." The central issues involved might be characterized as follows:

> Democratizing school administration. A key feature of the new proposals is building-based management of schools, under which teachers themselves play a significant role in management. The concept of "teacher leadership" appears frequently in these discussions (Barth, 1988; Sirotnik & Clark, 1988).
>
> Teacher self-management and professional development. Teachers are to have an important role in making professional decisions. These include: selection of curricula, instructional materials, teaching approaches; decisions on research to be carried out; evaluation of peers both for entry into the profession and for merit and advancement; and design and implementation of further professional education (Lieberman, 1986; Shulman, 1987).

Altered classroom roles and emphasis on critical thinking skills. Teachers are demanding professionally significant changes in traditional classroom arrangements. These include many shifts that technology can make possible--a change from being the source of knowledge to being a guide or coach to students; a change from frontal instruction to diversified classroom activities; and an expanded variety of instructional models and practices recognized as legitimate. One key aim of these practices is to increase students' abilities to reflect thoughtfully on what they have learned, not merely regurgitate facts (e.g., Sternberg, 1985; Tucker, 1985).

New modes of research on teaching and teacher preparation. These changes involve the role of colleges of education and their faculty. Colleges are to work more closely with teachers in defining teacher preparation courses; there is to be less emphasis on courses in pedagogical methods that do not meet teachers' practical needs (Holmes Group, 1986; Task Force, 1986). Faculty are to work directly with teachers in "professional development centers". Research should include anthropological study of classrooms and examinations of teachers' professional thought-in-action.

Educational Technology and Educational Reform

Teachers increasingly are demanding a larger say in how schools are organized and run. Assuming that teachers will not accept educational technology unequivocally and enthusiastically as either "new tools" or "systematic engineering," what role might there be for technologists either in supporting the reform of schooling or in providing useful data to policy makers? Several directions suggest themselves immediately: (1) preparation of models of teaching-with-technology, (2) design of software, (3) creation of computer-based tools to support teachers' professional development, and (4) improvement of research. These are discussed below as an agenda for improving the use of technology in education.

Development of models of teaching-with-technology. Teachers' everyday classroom work involves great uncertainties regarding instructional methods and outcomes (Floden & Clark, 1988). Thus, teachers' models of teaching--mental images of how a classroom should look and feel, ideas about activities, ways of integrating instructional materials with lessons--are often less organized and less goal-oriented than technologists would prefer. Rather than try to supplant the models and practices that teachers have developed to cope with the uncertainties of their world, we should be trying to develop models of teaching-with-technology (in the sense of using tools, materials, and approaches) that recognize those problems, seek to alleviate their impact, and provide at the same time the opportunity for teachers to expand their thinking about what is possible in the classroom.

The first part of this task is therefore to understand better teachers' models of daily classroom activity, what place technology has in those models, and what meaning technology has in the context of the constraints and uncertainties with which teachers must deal. Part of this investigation of meanings must deal with the unconscious assumptions that teachers, students, and parents make about the role and value of technology in education, how successes or failures are ascribed to persons, materials, or approaches. Another part must probe teachers' motivations and sources of reward in teaching, and consider those in relation to what technology either provides or takes away.

Improved information about the realities of the teacher's world, about the perceived role and value of teaching, of various teaching activities, and of the use of technology in teaching, can then feed the development of models of teaching-with-technology. Several desirable features of such models are clear: most importantly, they should accept the constraints under which teachers must work while they also expand the teacher's idea of what is feasible; they should reduce a teacher's burden of unrewarding classroom work (e.g., repetitive tutoring, grading exercises), buttress a teacher's position as guide and mentor for students, and demand minimal extra time for preparation; they should also be supported by appropriate prior training.

Unfortunately, creating and disseminating such models has been difficult. While there have been important demonstration projects that show what technology can do in selected classrooms (e.g., GTE's "Smart Classroom"; WICAT's Waterford School), these have usually focused on what can be done under optimal conditions, rather than on attempts to integrate technology-as-tools and technology-as-process into environments of typical schools and teachers. They have also routinely stressed the massive infusion of hardware plus a complex of software developed according to a single model of instruction. Teaching-with-technology requires more than a Stakhanovite approach to demonstrating what is possible. More important than demonstration centers or schools, in-service workshops, or summer institutes, are models that provide a well-articulated vision of how a particular approach can work in a real classroom (cf. other work on teaching models and how best to communicate them to teachers--Joyce & Weil, 1986; Weil and Joyce, 1978a, 1978b, 1978c).

One useful approach to the development of such models may be through the work currently being done at Stanford by Lee Shulman and his associates in a project entitled "Knowledge Growth in a Profession." This work illuminates relationships among curriculum content, instructional strategies and approaches, and the underlying structure of disciplines. While those who train teachers and instructors often assume that there are many generic teaching strategies, the findings from this project suggest otherwise. Although there are indeed a few strategies that are general (included in what Shulman and his colleagues call "General Pedagogical Knowledge"), there is a larger set of information about instructional strategies that is linked directly to the structure of disciplines and the syntactic relationships among concepts and approaches in discipline-specific fields(Shulman, 1987).

Called "Pedagogical Content Knowledge," this information includes knowledge of students' understandings and misunderstandings, curricular knowledge, conceptions of how to teach the subject, and a subject-specific instructional repertoire. It may be that teachers' definitions of the place of technology in teaching (see, e.g., Grossman & Gudmundsdottir, 1987, on textbooks]) are intuitively more discipline specific than we have thought. If so, this needs to be discovered.

Development of supportive software. The large initial enthusiasm for the use of computers in education is now being tempered by a realization that software needs to provide more than intriguing games or electronic workbooks. There are two particular problems with instructional materials that are also related to the reform agenda, problems that educational technologists could profitably address.

First, there is the problem of how instructional materials are designed and tested. The changes inherent in school reform will require that technologists devote more time to initial needs assessment with teachers and that they put greater emphasis on user concerns throughout the process of design. This need is now being effectively acknowledged by human-factors psychologists and cognitive scientists working on interface design for general-purpose and business software (e.g., Norman & Draper, 1986; Carroll & Rosson, 1987). A further requirement for software products will be a greater degree of teacher control and modifiability (see Hativa, 1986, for an example). Critical here is for educational technologists to move as far as possible away from the earlier concept of "teacher-proofing" materials.

A further useful approach is to provide teachers with programs that are instructive to both student and teacher (without being too obvious about addressing teachers), that support activities seen by the teacher to be clearly important. Pea and Kurland (1987), for example, offer a useful review of computer programs that may encourage development of writing ability. They maintain that the combination of directed planning, guided writing, and evaluation that the variety of writing programs now offer are close to a unified "cognitive technology." Authors of certain of the most successful pieces of recent computer instructional software (the Geometric Supposer, The Voyage of the Mimi) have maintained that these products have been consciously crafted to encourage learning on the part of teachers as well as students. Expansion of such efforts is at the heart of what needs to be done in order to make teaching-with-technology a reality.

Given the reform agenda, there are certain other approaches in designing and creating software that could usefully be exploited by educational technologists. One direction is the preparation of programs to allow more direct and regular interaction among students, and between teachers and students. New developments offer the possibility of enabling collaboration in ways not before feasible. While interesting work has been done to foster this kind of activity in joint writing or editing (Brown &

Newman, 1986), more could be done in other disciplines, especially to link technology with the current intense work to develop cooperative learning styles among students.

Programs that enhance motivation and excitement and the interest students have in learning are a further goal for technologists. Educational technology recently has paid too little attention to those practitioners whose original impetus for entering the field was to enhance students' motivation and interest. What is needed here is not unthinking use of game programs or entertainment software, but rather the creative incorporation of those elements of game design that engage students' capacities for fantasy, challenge, and creativity (Malone, 1981). Simulations that are open-ended and allow the student to construct meaning from a given situation (rather than building in the intended meaning, and assigning to the student the task of discovering it) are another goal for designers. Duckworth (1987) calls this approach "the having of wonderful ideas." Finally, there should be some attempt to create programs that strive for a "higher literacy" in the forms that new technologies make possible (e.g., Lee, 1985/86). Those concerned with ID need to recognize that there is value to openness as well as specificity.

Support for the education and further professional growth of teachers. It is a truism that teaching as an occupation needs to become more of a profession. In practice, this means improved education for teachers before they start their careers, and, once they have embarked on it, enhanced capability to manage their own work, to communicate with peers about common problems, and to improve practice through research and evaluation. Technology-based tools that encourage teacher professionalism could thus also make educational technology more useful to teachers in general.

Teacher training clearly needs to incorporate more information about and experience with educational technology, both hardware/software and process. But presenting these concepts in an isolated class (as is still required in many states) seems hardly the way to go. More useful in teacher education would be modeling of appropriate use of technology in general pre-service courses (both those in education and in the liberal arts), combined with placement as a student-teacher in a setting where the student teacher would encounter experienced teachers exemplary in their use of technology. While there have been calls for action (AACTE, 1987; Education, 1986; OTA, 1988), appropriate modeling of technology during teacher education is still much the exception rather than the norm. The new "professional development centers" called for in some reform proposals (to link schools, pre-service teacher education, and in-service training fro teachers) may be the places to provide experiences of this kind.

For practicing teachers, technology has already provided some useful lower-level software tools to enhance the professionalization of their position--spreadsheets for grading and assessment; word processors for routine administrative reports, letters to parents, and preparation of instructional materials; databases for keeping track of resources or student work. The problem here is more one of routine access than utility. A computer will not help in these tasks if the teacher must wait to use it, or if it is located inconveniently. Some school districts have successfully given computers to teachers to use at home, intending thus both to solve the problem of access and to aim for transfer of resulting skills to classrooms.

On a higher level, the impact of technology on teachers' professional work remains to be felt. Efforts have been made to encourage professional interchange among teachers using bulletin board programs (e.g., Harvard ETC's Computer Conferencing Project--see Educational Technology, 1988). Teacher-oriented computer software to support collaborative evaluation and research are not yet common, but the flurry of interest in tools to aid computer-based collaborative work in business (e.g., DeSanctis & Gallupe, 1987) may lead to more interest in creating such programs for education.

Technological systems for gathering, collating, analyzing, and disseminating data about student performance could also help to make teachers' work more professional. Part of this process begins in teacher training, where students are not now commonly urged to become what Richard Elmore calls "voracious producers and consumers of information" about all aspects of school performance (personal communication, July, 1988). Neither are most teachers now given the opportunity to develop such skills in their daily life. In many school districts, student performance data are kept relatively secret not only to provide confidentiality for student records, but also to protect administrators and principals from potentially embarrassing inquiries regarding problems in teaching and learning, "disproportionality" in achievement by students from different SES or ethnic backgrounds, etc. Technology can break such barriers and improve the circulation of information both for the assessment of individual student needs and (more importantly) to allow teachers as professionals to "take the temperature" of the systems in which they work. Moving to such an information-based professional culture is not likely to be easy; it is a problem faced by many organizations under today's of rapidly spreading technology for creating and disseminating information on which management decisions can and must be made (see, for example, Zuboff's [1988] excellent treatment of such effects in industry).

Improvements in research on teaching-with-technology. Research on technology in education is improving, but many changes in both method and assumptions are necessary. There is now a strong consensus that technology-as-hardware does not enhance student learning (Clark, 1983). One needed approach is an emphasis on field experiments and a comparative examination of the application of technology in ways that are sensitive to differences in context (Becker, 1988). Others (e.g., Perelman, 1987) have urged an approach to research and evaluation regarding technology so as to encourage diversity among schools, and thus foster innovation and change instead of bureaucracy.

But these approaches, while desirable, leave pressing concerns of teachers unaddressed--the meaning of technology in their own day-to-day activity, the "look and feel" of classrooms in which teaching-with-technology has become the norm, and the internal habits of mind that teaching-with-technology imposes and encourages. While there have been some interesting studies (e.g., Olson, 1988; Parker, 1986; Wiske et al., 1988), much more needs to be done. This is the research agenda technologists must grapple with if they wish to take part in the second wave of the educational reform movement.

Several specific approaches could garner new information useful both to educational technologists and to policy makers concerned about how to implement technology-based programs. One needed new direction is increased emphasis on estimation of program feasibility. In a context where time demands on teachers and students are increasing, not decreasing, and where fiscal resources are limited, educational technologists are frequently called upon to estimate not just the costs of a program or the likelihood of its overall success, but rather the probability that it will make some measurable and valuable contribution to the overall educational program of the school or district. Educational technologists should also be able to make reasonable estimates of time constraints and of the difficulty for teachers, students, and administrators of learning new systems and new approaches.

Also crucial is the need to move away from the present focus on measuring low-level, short-term cognitive outcomes and toward an approach in which *long-term changes* in cognitive style and personal well-being are assessed. The concerns that teachers, administrators, and parents have about the use of computers, for example, frequently have to do not only with immediate learning, but also with more general and long-lasting patterns of thought and action. Parents' fears that their children will develop to be computer "hackers" fall into this category, as do concerns about the longer-term impact of intensive use of computerized work environments, or of exposure to television (see, e.g., Ong, 1982; Meyrowitz, 1985; Palmer, 1989; Pool, 1983; and Turkle, 1984, on these trends).

Conclusion: Radical Reform and Teaching-with-Technology

Radical reform requires radically new ways of thinking about schooling. It demands that we recognize the importance of schools as social institutions, and of teachers as the agents principally responsible for effecting education. Using technology to define and strengthen teachers' roles, to empower them in their institutional context, to allow them to find and amplify their voice, will lead to a truer and more effective linkage of teaching and technology, a linkage that can also contribute to important broader changes now under way in education.

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Title:

The Relationship Between Elementary Teachers' Psychological Types and Their Uses of Educational Computing

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The Relationship Between Elementary Teachers' Psychological Types and Their Uses of Educational Computing

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The Relationship Between Elementary Teachers' Psychological Types and Their Uses of Educational Computing

PURPOSE

Many factors operate within a school to determine both the quantity and quality of a student's computing experience; one critical factor is the classroom teacher (Knupfer, 1987a, 1987b). The influx of microcomputers into American schools has been viewed differently among teachers, leading some teachers to use computers with their students while others do not. Further, teachers who do use educational computing do so in a wide variety of ways.

Because the teacher's role is central in determining a student's computing experience, the field needs to be able to specify factors which make one teacher an enthusiastic user of educational computing while another teacher refuses to use the technology. One factor which might influence teachers' decisions about using computers and further, the type of usage they employ, is their "psychological type." Although many studies have investigated psychological type as a factor in career decisions and group dynamics, none have explored it's impact on teachers' decision-making processes within the areas of instructional computing.

The objective of this study was to investigate the relationship between elementary teachers' "psychological types" and their uses of instructional computing. "Psychological type" was determined by the Myers-Briggs Type Indicator (MBTI), a standardized instrument developed to help understand how people perceive experiences and decide what to do about them. .Uses of instructional computing were determined by teacher interviews and logs of students' computer usage.

The researcher sought first to determine if there was any relationship between the teachers' "psychological types" and their decisions to use/not use computers. For computer-using teachers, the researcher further sought to determine if there was any relationship between particular kinds of computer use and teachers' "psychological types."

Significance

Because computers are playing an increasing role in all aspects of American society, it is critical that all students have some familiarity with computer technology (Barbour, 1989). However, some teachers refuse to use computers, causing their students to miss the opportunity. Lack of opportunity to use computers may be particularly damaging to minorities, young women, or less well-behaved students who have traditionally had less access to technology (Edwards, 1984; Komoski, 1983; Lautenberg, 1984; Nathan, 1983; Schubert & Bakke, 1984). In planning for instructional computing teachers need to consider equity for those student groups as well as for students of different ability groups.

One step toward promotion of equitable educational computing is to provide teacher education based on a better understanding of the machine/human interface, including the dynamics of teachers' decision-making about computer use. This study investigated "psychological type" as a factor which might influence teachers' decisions about computer usage. It further proposed to allow information about instructional computing to emerge through teacher interviews. The resulting factors which influence teachers' decisions can be considered in developing training programs for preservice and inservice teachers. Such training might be designed according to the MBTI suggestions for accommodating individual learning and teaching styles (see Myers, 1975).

LITERATURE REVIEW

Several studies have documented teachers' ongoing confusion about how to integrate computers into the traditional classroom structure and resulting inequities in students' computing experiences (Alvarado, 1984; Anderson, Welch & Harris, 1984; Becker, 1986; Edwards, 1984; Jungck, 1985; Knupfer, 1987b; Lesgold & Reif, 1983; Schubert & Bakke, 1984; Sheingold, Kane, Endreweit, & Billings, 1981). Quantitative inequity prevails when the machines are not available and qualitative inequity results from differences in the type of instructional use (high skill level and low skill level) to which students are exposed. If low-level activities encourage rote memorization under the control of the program, and high-level activities promote independent thinking and stimulate curiosity, then the degree of the learner's exposure to these techniques can either stunt or improve their cognitive abilities (Knupfer, 1987b; Patterson & McLellen, 1986). The selection of instructional activities therefore, can promote or retard the learner's heuristic, cognitive development, putting a premium on assuring not only equal access to computers for all students, but also on equal access to the different kinds of educational computing activities.

The method by which any innovation is implemented is significantly more important than the actual subject of the implementation in determining the innovation's success (Berman & McLaughlin, 1976). It follows that the way computers are used is more important than the fact that the machines are sitting in school buildings. Recent research has shown that a final arbiters of classroom activities, regardless of administrative mandates, teachers will shape any implementation effort to fit their own situations (Cuban, 1986; Fullan, 1982; Jackson, 1978; Weinshank, Trumbull, & Daly, 1983).

A study of teachers' reactions to instructional computing (Knupfer, 1987b) revealed that less than 30% of the elementary teachers used computers. Further, teachers believed that average and remedial students were limited to software which promoted low-level thinking skills, while advanced students used the computer mostly to promote the higher-level thinking skills. In spite of common complains of time shortage, inadequate training, poor software, and lack of both equipment and program objectives, Knupfer found that there were some teachers who attempted instructional computing while other teachers flat out refused. Knupfer suggested a need to investigate factors which might influence teachers' decisions to use or not use instructional computing.

One measure of the way people make judgments and decisions is the Myers-Briggs Type Indicator.(MBTI). This instrument is based on the work of Carl Gustav Jung, who published *Psychological Types* in 1921 as a way of helping people to understand themselves and others (O'Brien, 1985). According to Jung, people differ in their perception and judgment styles. Perception is the way they become aware of things and judgment is the process of reaching conclusions about those things. People can perceive things in two distinct ways, by sensing or by intuiting. Sensing individuals tend to prefer concrete facts and are good with details, while intuiting people tend to be more creative and dislike routine. People are also able to make judgments through two distinct methods, thinking and feeling. Thinking people evaluate information in an impersonal, logical fashion, while feeling people evaluate information on the basis of values.

Isabel Briggs Myers and Katherine C. Briggs expanded on Jung's theory and in 1943 constructed the four dimensional MBTI to measure type preferences (Myers, 1962). Among other things, the MBTI has been used to study groups of people (Graves & Graves, 1973), the performance of school principals (Brightman, 1984), teachers' behavior (DeNovellis & Lawrence, 1983), and student achievement (Myers & McCaulley, 1985). Although various researchers have used the MBTI to study teachers and some have even tried to change the teachers' "psychological types" through directed instruction (Dettmer, 1981), no one has investigated the relationship between teachers' "psychological types" and their reaction to instructional computing.

METHOD

Subjects

The subjects were sixty elementary (K-6) school teachers who teach on a full-time basis across the general curriculum. The teachers represented three schools, all within the same general neighborhood and with the same socio-economic status. Each school had a large population of minority students and each qualified for Chapter I funding. After a decision from the principal and the teachers' "computer committee", all teachers (29) from one school were included in the study. The researcher solicited volunteers from the other two schools; the second school had a sizable number (21) and the third school had the fewest (10).

Materials

Myers-Briggs Type Indicator (MBTI) -- The MBTI is a questionnaire used widely in counseling, psychology, and education to determine "psychological type." The essence of the MBTI is that behaviors are influenced by the way in which people prefer to take in information and make decisions. Four preference types are measured: 1) Extroversion/Introversion (attitude toward life); 2) Sensing/Intuition (two kinds of perception); 3) Thinking/Feeling (two kinds of judgment); and, 4) Judging/Perceptive (attitude for dealing with the environment) (see Figure 1). The instrument, which was developed during the 1940s and revalidated in 1977, is both reliable (95%) and valid (Myers, 1975).

The instrument categorizes people into 16 different types based upon a combination of the four scales (see Figure 2). The MBTI is not meant to stereotype people, but to indicate their preferences when making judgments and decisions. Each type has certain characteristics by which it can be recognized, but no type is rigidly set. In any practical sense, it would be difficult to address the needs of 16 different "personality types" when planning teacher training within any one school building, so this study focused on the four main variables that comprise the 16 types.

Two versions of the instrument contain 126 (Form G) or 166 (Form F) questions., and a shorter 50 question version (form AV) was recently released. Although the shorter version is self scoring, it is not nearly as reliable as the longer versions. This study used Form G, which is now the standard. The subtle questions indirectly tease out the type preferences through forced-choice answers between two possible responses.

Interviews -- Unstructured interviews (Guba & Lincoln, 1981) with the teachers elicited information about decisions regarding computer use. The interviews included a set of common questions to serve as a base, such as "What effect has educational computing had on the structure of your curriculum?" and "What are some problems you've had with instructional computing?"

Student Logs -- Student-maintained logs of computer activity, including the frequency, duration, and kind of task were monitored by the researcher. When using courseware, the students noted the title of the courseware and what they did on the log. The researcher determined what kind of activity (low-level or high-level) the courseware represented. The logs collected actual data about the students' computer use, which could be compared to teachers' beliefs about that use.

Hypothesis

This research tested the null hypothesis that there is no relationship between teachers' "psychological types" and their reaction to instructional computing. Reaction included the teachers' decisions to use or not use computers, their participation in training, their attitudes about computers in the schools, and the kinds of educational computing utilized.

Procedure

In order to gain access to the schools for this study, the researcher traded the opportunity to do research for computer inservice presentations at each school involved; each principal decided whether to have one, two, or three inservice sessions. The study itself was conducted over the full course of the second semester and culminated during the last week of school.

The MBTI was administered to all teacher participants in mass at each of the three schools. The researcher gave the teachers an overview of the MBTI and told them that the instrument would help indicate how they made judgments and decisions, including their decisions about their jobs as teachers. The MBTI should not be administered without some sort of explanation, so the researcher was allowed approximately an hour to conduct a training session about the MBTI and how teachers could used their knowledge of "psychological type" to enhance their relationships with fellow employees.

The researcher instructed the teachers about maintenance of the student computer logs, and the teachers explained the logs to their students, reminding them periodically to maintain the logs throughout the semester. A log was attached to each computer, so that if the computer moved, the log went with it. The researcher monitored the logging of computer activity as much as possible, but could not be present at all times.

During the semester, the researcher observed each teacher conduct a lesson and engaged in an interview with each teacher. The interview information and the student log information was compared to the four MBTI dyads and analyzed for statistical significance.

Data Analysis

The data analysis first employed chi-square tests of independence to evaluate relationships between teachers' use/nonuse of educational computing and "psychological type." Then among teachers who used educational computing with their students, the chi-square statistic tested relationships between the teachers' "psychological type" and patterns of computer utilization. Data from the interviews were grouped according to emergent categories, reported with summary statistics, and then analyzed with the chi-square statistic when appropriate. Several questions which measured positive attitude on a Likert-type scale were grouped together and a t-test was conducted to check for differences in the means. For all tests, significance was set at the .05 level.

RESULTS

Of the sixty subjects in this study, 58 were present to take the MBTI. One did not want the results revealed to anyone, including the researcher, so there are 57 valid cases. The frequency distribution of MBTI categories is reported in Figure 3.

Contingency tables were constructed and chi-square tests on each MBTI dyad (E-I, S-N, T-F, AND J-P) revealed no significant relationship between the type of teachers who used instructional computing. and those who did not . However, this measure is limited by two factors : 1) the first school (29 subjects) required all teachers to send some students to the computer lab, and 2) subjects from the other two schools participated on a voluntary basis which might have skewed the data for this measure. A second analysis eliminated the first school and checked for relationships between the second and third schools, both of which housed the computers within the classrooms; no significant relationship was found.

Teachers who used computers at least once during the schoolyear were tested for relationships between their MBTI type and the kind of computer use, as well as for relationships between the MBTI type and which students used the computers. There was no significant relationship found in either of the tests. The type of computer activity in each of the three schools was solely drill and practice, with two exceptions; school one taught sixth grade students to use a word processor and school two allowed some students to use some popular simulation software. Unfortunately, the word processor use was not tied into the curriculum, so students did not apply the tool to their work.. Also, the students at school two usually spent less than 10 minutes at the computer, making it difficult to complete a simulation.

The chi-square statistic revealed a significant relationship between specific MBTI dyads and several dependent variables: the amount of training teachers had taken through district-supported computer classes (with E-I), feeling of adequacy of training (with S-N), whether or not the principal encouraged computer use (with S-N), factors which make it difficult to use instructional computing (with J-P), and opinion about the quality of available software (with J-P and T-F).

District-Supported Computer Classes. It appears that the majority of both E and I types had taken no district computer classes at all, but the percentage of those who neglected classes was larger among introverts than extroverts. About one-fifth of the extroverts had taken one class (see Table 1).

Adequacy of Computer Training. Although sensing and intuiting people had equivalent amounts of training, the feelings of adequacy of that training was not independent on the S/N variable. Most Ss and Ns believed that their training was totally inadequate, but on the whole Ss indicated less satisfaction with their preparation than Ns (see Table 2.

Principal's Encouragement to Use Computers. The reactions of the teachers to district or principal encouragement to use computers is significantly related to their S-N type. A larger percentage of Ns reported either no encouragement all or encouragement through training opportunities within the district, while a large percentage of Ss claimed that the district or principal encouraged computer use by providing hardware or software. In other words, the Ns perceived themselves as receiving little support, but if they wanted training they could seek it through district computer classes. Ss believed there was more tangible support offered within their immediate work situation (see Table 3).

Factors Which Make it Difficult to Use Computers. Judging and perceptive people did not agree on the things that make it hard to use computers within a school setting. Table 4 shows a significant relationship the teachers' J-P type and their answers regarding obstacles to Instructional computing. The majority of judging people believed that the computer lacks meaning within the curriculum, while the largest consensus among perceptive people revealed access to equipment (both hardware and software) as the largest deterrents to computer use

Quality of Educational Software. The teachers' responses to the quality of educational software showed a significant relationship between their viewpoints and both the J-P and T-F MBTI dyads. Most judging people and feeling people claimed that educational software is of good quality, while a large percentage of perceptive people and thinking people believed that they were unqualified to answer the question. In other words, the perceptive people and thinking people did not know what to think of the quality of educational software, while the judging people used logic and the feeling people used values to determine that the software was of good quality (see Tables 5 and 6).

Finally, differences in the means of the teachers' positive attitude toward computers based on their MBTI types was measured for significance with a t-test. The test revealed that the mean was slightly more positive than neutral for each group; no group was very positive and no group was very negative. There were no significant differences in degree of positive attitude between any of the MBTI types.

According to observations and teachers interviews, the school principal was the most influential person in determining how computers were used in each school. The principal was responsible for encouraging and providing direction for computer use. Each principal made decisions about how computer resources would be acquired and distributed among teachers and students. And, the degree of faculty and staff involvement closely reflected the principal's direction.

The first school had a principal who actively promoted computer usage for all students. Although the majority of the computer resources were purchased with Chapter I funds, the principal placed the computers in a laboratory setting and encouraged all teachers to send students to use the lab on a weekly basis. This principal established a committee of teachers to deal with computer-related issues and actively sought the committee's recommendation prior to making final decisions. Teachers in this school believed that the principal actively helped them to learn about computing. This principal welcomed the researcher and encouraged the researcher to get involved with the school's computer curriculum. The principal planned to increase each teacher's lab time from one 20-minute session per week to two 20-minute sessions per week during the next school year. The major factor inhibiting the teachers' involvement with instructional computing was the lab situation. While the lab aide conducted the computer sessions with a partial class of students, the teachers kept the remaining students in the classroom or completed other duties. The teachers did not feel motivated to sharpen computer skills because they believed they would not need the skills nor get a chance to use the skills with their students. As a result, the computer lab operated without the benefit of curriculum coordination with the classroom activities. The researcher conducted three inservice training sessions for the teachers at this school. All were well-attended; probably because the principal was trying to get additional computers to place within classrooms for the following year.

The principal at the second school did not seem very supportive of the computer curriculum. That principal was not available to meet with the researcher and did not have a plan to help teachers use the computers with the students. The computers were distributed among the classrooms so that each grade level (three classes of approximately 30 students) shared one computer. There was a limited supply of software which was housed in the library/media center with hopes that it would be available for teachers to check out. Unfortunately, the software was in a state of chaos, with no organization and no clear instructions for teachers about the content or workings of the software. Most teachers were very hesitant to explore the computers or software on their own and as a result, the computers were used by a limited number of classrooms. The method of distributing one computer per grade level might be sound in theory, but in actual practice this method allowed some of the computers to remain totally unused for the schoolyear; few of the teachers in this school sought a computer with gusto. One teacher believed the computer in her classroom didn't work, but the researcher found that it was not plugged in and the teacher did not know how to insert a disk. In a similar situation, a teacher knew there was a computer to share among three classrooms, but did not realize that it had been in her classroom all year (nor did her two colleagues know which room it was in since they had no interest in using it). The researcher planned to conduct two inservice training sessions in the spring, but due to demoralization of the teachers, that did not happen. A large number of teachers came to the first session, but only to announce that there was no point in receiving the training. The principal had decided to use a lab situation the following schoolyear and restrict the computers to Chapter I students, who would be supervised by one adult Of course, the teachers were demoralized. This was particularly disappointing in contrast to the original enthusiasm of the staff when they first volunteered to help with the research on instructional computing.

The third school in the study enjoyed a principal who supported instructional computing by setting an example for students and teachers. This principal allowed students to use the computer in the school office as a reward for school accomplishments, academic or behavioral. A teacher, who had been assigned as the computer specialist, supervised rotation of the software and hardware among classrooms. That teacher also conducted two inservice sessions per year and was available for individual consulting on a daily basis. The teachers in this school seemed split on their level of enthusiasm. A particular group of young, enthusiastic teachers volunteered to participate with the study, but several teachers who chose not to use computers also chose not to participate in the study. The principal and the computer specialist decided to put the computers in a lab during the next year and provide software via a networked system.

It appears that more teachers believe their students are using computers than is the case. This is evidenced by the fact that 14 teachers admitted not using computers at all during the school year, but the student logs revealed that 22 teachers did not send students to the machines. Perhaps teachers feel that they must claim a willingness to send students to use computers. If that is not the case, then perhaps students were forgetting to fill out the log sheets. In any case, students were not getting any high-level use of computers in any of these three schools. All exercises dealt with running drill and practice software, or learning to manipulate a word processor, but not actually using the word processor for productive purposes. Only one teacher felt well-enough trained to incorporate computers into the curriculum at all; the others simply had the students run drill and practice software that was unrelated to their classroom work. Only two teachers actually had all of their students use computers during some point in time. The pattern of student usage indicates that the teachers are letting advanced and average students use the computers more than the remedial students, but that not all average and advanced students in a classroom use the computers either. Rather, the most popular method of allowing usage was to select specific students from among the class to use the computer. Those specific students were usually those who had their other work completed, and the computer activity was not coordinated with classroom work. These general patterns carried across all three schools and all MBTI types.

CONCLUSIONS

The principal is a very influential to the course of instructional computing. The principal not only makes decisions which affect the students and computer equipment, but which also greatly affect the teachers and their attitudes toward instructional computing. A supportive, informed principal is needed to promote and maintain enthusiasm for instructional computing among the teachers.

There is a need to find a way to help introverts get started with district computer classes. Introverts like thinking about ideas, so training for them might consist of several problems or meaningful challenges to complete. Such meaningful training does not simply lecture or deal with the abstract, but involves the learner in the learning process. Also, pay particular attention to making the training meaningful to sensing-type people. These people need to feel that the training is worthwhile in terms of the curriculum as well as their ability to master the manipulations of the hardware.,

Although sensing people feel that access to hardware and software are helpful, the intuitive people will need more than just equipment. School districts will need to make sure to provide training that is specific to the equipment and software that they are placing in the schools so that intuitive people will feel comfortable using that equipment.

Teachers need training in software evaluation so that they can tell good software from poor software. They also need training in incorporating the computer into the curriculum so that it can be used meaningfully. Without such direction we will probably see teachers continue to send students off to computers to run low-level software and never take advantage of the opportunity to link the computers to their classes in a meaningful way.

Construct a better way to observe actual student usage of the computers so that information can be collected in a more systematic, accurate manner. This study was able to show that teachers do tend to send students of mixed ability to use computers, but that access is often based on getting other work finished first. Although there is no significant test of this, the trend is obvious within the student logs and the teachers' interviews. In order to provide equitable access to instructional computing, teachers will need to consider both the quantity and quality of students' time at the computer. And to enable teachers to do so means supporting teachers with meaningful training.

The ideal situation might include specific training techniques aimed at particular MBTI types, but in reality that will probably have little chance of being addressed.. An alternative is to realize that teachers do have different MBTI types which affect their judgments and decisions about instructional computing. When possible, consider the relationships revealed as significant in this study and direct training to accommodate the different preferences, rather than just one. For example, trainers need to realize that S types need to be taught how to generalize beyond immediate facts, that N types need to become more accepting of traditional methods, that S and P types respond well to rewards, and that N types need to be coached to pay more attention to detail (Myers, 1975). Myers also found that different MBTI types respond differently to different styles of instruction, so trainers need to balance their method of delivery between Bruner's, Gagne's, and Ausubel's methods if they are to address a mixed group of MBTI types..

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Figure 1 - Four Myers-Briggs Dyads

Extroversion -------------------- ATTITUDE TOWARD LIFE -------------------- Introversion

Sensing ------------------------------- PERCEPTION ------------------------------- INtuition

Thinking -------------------------------- JUDGMENT ---------------------------------- Feeling

Judging -------- ATTITUDE FOR DEALING WITH THE ENVIRONMENT -------- Perceptive

Figure 2 - Sixteen Myers-Briggs Combinations

	Sensing Types		Intuitive Types	
	w/Thinking	w/ Feeling	w/ Feeling	w/ Thinking
Introverts				
Judging	ISTJ	ISFJ	INFJ	INTJ
Perceptive	ISTP	ISFP	INFP	INTP
Extroverts				
Perceptive	ESTP	ESFP	ENFP	ENTP
Judging	ESTJ	ESFJ	ENFJ	ENTJ

Figure 3 - Frequencies of MBTI Types

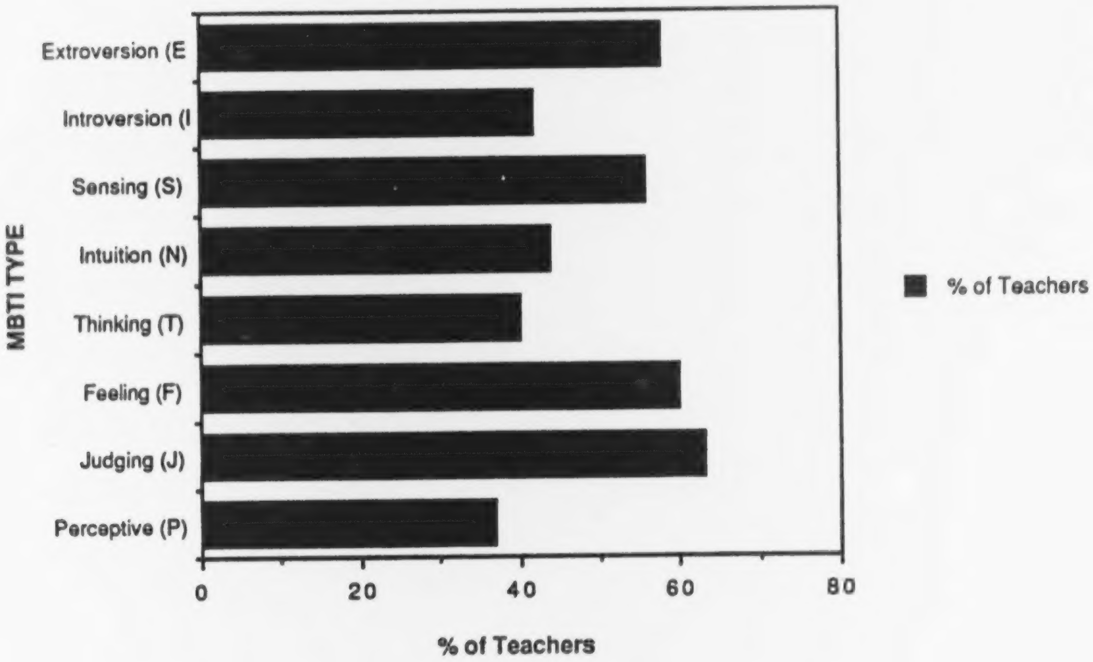

Table 1 - Number of District Computer Classes by E/I

COUNT EXPECTED COLUMN % TOTAL %	EXTROVERT (E)	INTROVERT (I)
DISTRICT CLASS		
None	26	21
	27.2	19.8
	78.8%	87.5%
	45.6%	36.8%
One	7	1
	4.6	3.4
	21.2%	4.2%
	12.3%	1.8%
Two	0	2
	1.2	.8
	0%	8.3%
	0%	8.3%
COLUMN TOTAL	33	24
	57.9%	42.1%

CHI-SQUARE = 5.75 SIGNIFICANCE = .05

Table 2- Adequacy of Training by S/N

COUNT EXPECTED COLUMN % TOTAL %	SENSING (S)	INTUITION (N)
ADEQUATE TRAINING		
Totally Inadequate	15	12
	15.2	11.8
	46.9%	48.0%
	26.3%	21.1%
Somewhat Inadequate	6	0
	3.4	2.6
	18.8%	0%
	10.5%	0%
Adequate	4	10
	7.9	6.1
	12.5%	40.0%
	7.0%	17.5%
Somewhat Adequate	2	0
	1.1	.9
	6.3%	0%
	3.5%	0%
Very Adequate	5	3
	4.5	3.5
	15.6%	12.0%
	8.8%	12.0%
COLUMN TOTAL	32	25
	56.1%	43.9%

CHI-SQUARE = 10.70 SIGNIFICANCE = .03

Table 3 - Is Computer Use Encouraged? by S/N

COUNT EXPECTED COLUMN % TOTAL %	SENSING (S)	INTUITION (N)
IS COMPUTER USE ENCOURAGED?		
Not At All	4	9
	7.3	5.7
	12.9%	37.5%
	7.3%	16.4%
Computers Available	21	8
	16.3	12.7
	67.7%	33.3%
	38.2%	14.5%
Training Offered	6	7
	7.3	5.7
	19.4%	29.2%
	10.9%	12.7%
COLUMN TOTAL	31	24
	56.4%	43.6%

CHI-SQUARE = 7.05 SIGNIFICANCE = .02

Table 4 - What Makes it Hard to Use Computers by J/P

COUNT EXPECTED COLUMN % TOTAL %	JUDGING (J)	PERCEPTIVE (P)
MAKE IT HARD		
Do Not Know	4 5.6 11.4% 7.1%	5 3.4 23.8% 8.9%
Access	12 11.9 34.3% 21.4%	7 7.1 33.3% 12.5%
Meaningful Training	16 11.2 45.8% 28.6%	2 6.4 9.5% 3.6%
Space	0 1.3 0% 0%	2 .8 9.5% 3.6%
Time	3 5.0 8.6% 5.4%	5 3.0 23.8% 8.9%
COLUMN TOTAL	35 62.5%	21 37.5%

CHI-SQUARE = 12.13 SIGNIFICANCE = .03

Table 5 - Opinion of Software Quality by J/P

COUNT EXPECTED COLUMN % TOTAL %	JUDGING (J)	PERCEPTIVE (P)
SOFTWARE QUALITY		
Do Not Know	6	9
	9.3	5.7
	17.6%	42.9%
	10.9%	16.4%
Terrible	2	4
	3.7	2.3
	5.9%	19.0%
	3.6%	7.3%
Good	19	7
	16.1	9.9
	55.9%	33.3%
	34.5%	12.7%
Excellent	7	1
	4.9	3.1
	20.6%	4.8%
	12.7%	1.8%
COLUMN TOTAL	34	21
	61.8%	38.2%

CHI-SQUARE = 8.71 SIGNIFICANCE = .03

Table 6- Opinion of Software Quality by T/F

COUNT EXPECTED COLUMN % TOTAL %	THINKING (T)	FEELING (F)
SOFTWARE QUALITY		
Do Not Know	7	8
	6.0	9.0
	31.8%	24.2%
	12.7%	14.5%
Terrible	5	1
	2.4	3.6
	22.7%	3.0%
	9.1%	1.8%
Good	6	20
	10.4	15.6
	27.3%	60.6%
	10.9%	36.4%
Excellent	4	4
	3.2	4.8
	18.2%	12.1%
	7.3%	7.3%
COLUMN TOTAL	22	33
	40.0%	60.0%

CHI-SQUARE = 8.40 SIGNIFICANCE = .03

Title:

The Effectiveness of a CBI Program for Teaching Problem Solving Skills to Middle Level Students

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The Effectiveness of a CBI Program for Teaching Problem Solving Skills to Middle Level Students

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The Effectiveness of a CBI Program on Problem Solving Abilities of Middle Grade Students

Problem Solving

Problem solving is a complex set of interdisciplinary skills and abilities that education has identified as a critical instructional topic. It has been identified as a subset of critical thinking that uses creative, conceptual, and thinking skills in unfamiliar situations (Feldhusen & Treffinger, 1977; Hoelscher, 1984). Educators have long been seeking methods of teaching problem solving skills to their students (Bransford, Stein, Declos, & Littlefield, 1986). There are several models for teaching these skills in the literature along with a myriad of materials available on the market.

The process approach is recommended by many authors, including Polya, Beyer, and Bransford and Stein. All of these authors advocate a series of steps that can be learned and applied to any new situation. Some suggest teaching problem solving within a specific content area and teach for transfer to other situations, others suggest using real-life problems to solve to aid in the learning of the process.

Computer

There has been a recent proliferation of materials available for the microcomputer that claim to teach problem solving skills. Why consider th computer for teaching problem solving? There are several possibilities for suggesting the computer as a teaching tool. First, it can present real-life problems that would be difficult or impossible without the computer. For example, the computer can collapse time so that students can see the results of their decisions promptly. The computer can also present situations that would other-wise be dangerous for students. Students can make decisions and see the results without fear of consequences. The computer allows for programs to be written to branch and send students in different directions depending on the decisions made.

There is, however, a lack of empirical evidence validating the use of computer as an instructional tool in teaching problem solving strategies to middle level students.

Purpose

The study described in this paper attempts to evaluate the effectiveness of one of those computer software programs developed to teach problem solving. Solutions Unlimited, a public domain software package, was selected because it was designed to be a comprehensive program for developing problem solving abilities in middle level students and its attempt to teach general problem solving strategies. The program follows a pattern of problem solving skills similar to those recommended by Polya (1957). There are eight units in the package, the first being a tutorial teaching the four step process for problem solving, "Hey Wait," "Think," "See," "So." The seven subsequent units are situational lessons that give the students opportunities to apply those steps. Use of real-life problems help students to realize that solutions are not always clear and that more than one solution may often be applied to the same problem. The lessons cover topics such as considering alternatives, judging sources of information, and drawing conclusions.

Investigation

Fifty-one middle level students attending a private school in a small community in the Mid-West were the subjects for this study. The students were enrolled in fourth, fifth, and sixth grades. There were twenty-one girls and thirty boys involved. None had received any prior training in problem solving. The students were randomly assigned to either a treatment group or control group.

All of the students completed the Purdue Elementary Problem Solving Inventory (PEPSI), developed by J.Feldhusen, as a pretest. The PEPSI uses a filmstrip and audio tape with paper/pencil response sheets. The PEPSI is designed to measure several skills appropriate to problem solving. The subscales on the PEPSI include such things as sensing that a problem exists, judging information, analyzing details, solving problems, and verifying solutions.

A computer lab setting of five computers was used for the experimental group instruction. The experimental group students were assigned to one of two instructional groups that met for forty-five minutes each. During the class period, the students in the treatment group were divided into computer work triads, small groups of three students each. The students worked on one lesson each week for eight weeks, starting with Unit 1, introducing them to the Solutions Unlimited materials. The teacher followed the directions accompanying the computer software to insure consistency within the experimental groups. The control group participated in a creative dramatics class during the same eight weeks. They were given an opportunity to use the computer software following the study.

At the end of the eight weeks all of the students completed the PEPSI again as a posttest. The difference score for each student was calculated. T-tests were used to determine the significance of the difference between the pretest and posttest scores.

Results

The results of the study did not indicate any significance in the difference scores of the treatment group. The students in both groups generally achieved similar change scores.

These results indicated that while the Solutions Unlimited program was specifically designed to teach problem-solving skills, the students participating in the instruction did little better in the posttest than did the students who had not received the direct instruction. There is speculation that the design of the PEPSI, used for measuring the change in scores, was not appropriate for the age group involved. The answer sheets should have been changed to discourage possible cheating and to appear less primary.

The program was well received by the students participating and they looked forward to the computer sessions. It may well be that problem solving cannot be taught for forty-five minutes once a week, but needs to be integrated into the entire curriculum. The strength of the computer program used is in its simulations that create realistic life situations. Students need to recognize that the skills used in that single situation can be applied in other similar settings. The suggestion, then, is to employ techniques for transfer of skills learned in the computer simulations to new and novel situations.

The literature suggests that problem solving and critical thinking skills cannot be developed in a short period of time, but rather may take several years to develop. We may be placing too high an expectation level on the students when we look for change after only a short period of time for training. This is one common problem with many of the research studies done in computer applications.

Further research using more age appropriate forms of the test and using the supplementary materials to teach for transfer is necessary. There is some provision for follow-up activities within the materials used in this study to stimulate the possibility of transfer of newly learned problem-solving skills to other situations. The present study did not allow sufficient time to complete any of those follow-up activities. A follow-up study is being designed that will investigate the possible change in scores when teaching for transfer has been added to the instruction.

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Title:

Secondary Computer-Based Instruction in Microeconomics: Cognitive and Affective Issues

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SECONDARY COMPUTER-BASED INSTRUCTION IN MICROECONOMICS: COGNITIVE AND AFFECTIVE ISSUES

Final Report

Presented to the Annual Meeting of the Association for
Educational Communications and Technolgy
January 1989
Dallas, Texas

By

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SECONDARY COMPUTER-BASED INSTRUCTION IN MICROECONOMICS: COGNITIVE AND AFFECTIVE ISSUES

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Abstract

This paper describes the general rationale, hypotheses, methodology, findings and implications in a recent dissertation research project conducted in the Columbus, Ohio, public schools. The computer-based study investigated the simultaneous relationship between achievement in microeconomics and attitude toward economics, level of computer anxiety, and attitude toward learning. Twelfth-grade students in regular social science courses (n=155) at four Columbus senior high schools were randomly assigned to two alternative instructional treatments. Each treatment, emphasizing either a problem-oriented strategy or a rule-oriented strategy, consisted of a week-long computer-based unit teaching fundamental economic concepts and principles of supply, demand, and equilibrium. Pre, post and delayed-post measures were given, and appropriate data analyses completed. Results of these analyses indicate that individuals receiving problem-oriented instruction performed at a higher level on all of the cognitive achievement scales, although this difference was significant only for questions on the lower-order subscale of Posttest I. There is also evidence that a problem-oriented strategy may positively influence attitudes towards economics, as well as the degree of sophistication towards economic issues generally.

INTRODUCTION

During the last fifteen years, the microcomputer has emerged as a dynamic, rapidly-evolving medium of instruction (Hall, 1982, 1978). Moreover, rigorous research into computer-based instruction (including interactive videodisc, hypermedia, and compact-disc technologies) has had a significant impact on the entire field of educational research, most noticeably in the study of individual differences in learning and the integration and application of a diversity of theories of concept learning, knowledge representation, and instructional design (Kearsley, Hunter, & Seidel, 1983). Evidence suggests that advanced technologies can be used to improve: (1) the rate of learning (Kulik, Bangert, & Williams, 1983); (2) the degree of learning achievement (Chambers & Bork, 1983); (3) the attitudes of students towards computers (Magidson, 1978); and (4) the motivation and interest in the learning experience (Kearsley, et al., 1983).

Also during this period, the development of curriculum and instruction in pre-college economic education has become increasingly important and widespread throughout the public schools of the United States (Walstad & Watts, 1985). In estimating the effects of various programs on student economic learning, most evaluation studies have only measured cognitive outcomes while often neglecting to measure affective learning and individual differences (Soper & Walstad, 1983). No studies have attempted to design and apply research-based microcomputer instruction in economics while analyzing the simultaneous relationship between achievement in microeconomics and attitude toward economics, level of computer anxiety, and attitude toward learning. The purpose of this study was to begin to address this problem, and to acquire a broader understanding of the complexity involved in the development of economics education courseware and concept learning in economics, as well as gain a deeper insight into the phenomenon of learning economics from computers across both cognitive and affective domains.

The rationale for this study was based on the emergence of two important phenomenon in educational theory and practice: (a) the systematic design, development and widespread implementation of computer-based instructional courseware in public school and commercial training curricula, and (b) the parallel development of the field of economic education and continuing research into the relationship between the affective and cognitive factors related to improving economic education across the academic curriculum. In particular, critical gaps in the literature existed in the design and evaluation of precollege computer-based instructional strategies in microeconomics and the investigation of the relationship between achievement in microeconomics concepts and attitude towards economics, economic attitude sophistication, level of computer anxiety, and attitude towards learning.

Problem-Oriented Instruction

Cognitive theories that broadly synthesize instruction and generative learning collectively argue that changes in behavior occur as a result of learning, and that learners construct meaning as they approach new content domains (Shuell, 1986; Wittrock, 1978, 1974). Cognitive-designed instructional systems encourage the learner to use heuristics, strategic tools and procedural knowledge during the process of concept acquisition and problem-solving (diSessa, 1977; Nickerson et al., 1985). Computer-based learning environments designed from a cognitive, problem-oriented model may facilitate the individual's ability to explore his or her thinking processes, deal with ambiguity, recognize underlying assumptions, and search for commonalities among data (Perkins, 1986). A basic rationale for the study was that exploratory research into both the structure and effectiveness of emerging technology-based problem-oriented strategies to teach specific subjects and knowledge domains is essential if such systems are to prove useful in addressing long-term instructional needs.

The underlying rationale of a "problem-oriented" pedagogy is that instruction can foster meaningful learning by emphasizing relationship and connectivity between information, concepts and principles within a relevant context (i.e., a problem scenario). Structuring the content around engaging, interactive problem scenarios, a "problem-oriented" adaptation of Reigeluth's Elaboration Theory (Reigeluth, 1983) approach to instructional design emphasizes the following elements: (1) early ideas in an instructional sequence should epitomize rather than summarize concepts, with the superordinate principles introduced first as the "glue" that provides the conscious framework for all subordinate concepts that are to follow; (2) specific cognitive strategies, analogies and models are both explicitly taught and embedded within the sequence, and provide flexible tools with which to approach problems within the domain; (3) concepts and principles are then synthesized through new applications which require increasingly sophisticated analyses and applications of the learned strategic skills and concepts; and (4) knowledge within a sequence is only then summarized before proceeding to a deeper level within the central, superordinate principle (an elaboration consisting of a more advanced epitome and complex problem). These specific considerations underlie the rationale of the experimental problem-oriented treatment in this study.

Rule-Oriented Instruction

Behavioral theories have been extensively applied to the new technologies of instruction, and have been the foundation upon which much of conventional computer courseware has been designed. These theories collectively argue that changes in behavior are learned, and that learners associate correct responses to stimuli in their environment as they approach new content domains (Skinner, 1954, 1958; Amsel, 1960). While the view of thinking as an operant learned response predated B.F. Skinner, the major catalyst in applying behavioral theory to programmed instruction in "learning machines" was the linear frame-based approach of Skinner (Lumsdaine, 1960). The deductive, step-by-step sequencing of Skinner's instructional strategy emphasizes unambiguous, impersonal, rote rule-example-recall sequences, followed by immediate reinforcement after a correct response (Merill & Tennyson, 1977; Scandura, 1964). Computer-based learning environments designed from a behavioral, rule-oriented model emphasize the following elements: (1) the function of the tasks is to deliver and provide practice in the comprehension of given rules and concepts within the content domain; (2) the tasks foster direct concept acquisition by presenting explicit, well-defined rules with multiple examples to illustrate and reinforce previously stated definitions of terms and principles; and (3) concepts and principles are organized in a consistent, predefined, linear, hierarchical sequence, with the broader, most comprehensive principle learned last, and only after all previous material has been delivered and learning systematically evaluated (i.e., mastery). These specific considerations underlie the rationale of the experimental rule-oriented treatment in this study.

Economic Education

The teaching of economic principles, knowledge and reasoning has become an integral part of the core curriculum in American schools across all grade levels K-12 (Clark & Barron, 1981; Walstad & Watts, 1985). The Joint Council on Economic Education has supported the development of computer courseware, film series, and other media to provide students with the economic understanding and problem-solving ability needed to deal with both personal and societal economic issues (Morton et al., 1985; Soper & Walstad, 1983; Walstad, 1979). There is a growing need for the improvement of economic education throughout the curriculum, and therefore research that investigated the interrelationship between achievement in economics and attitudes towards economics and learning would contribute to the continuing development in mediated instructional strategies in economics education, and may have additional implications to the teaching of thinking and problem-solving across many other content domains (Heiman & Slomianko, 1987; Nickerson, et al., 1985).

It was hypothesized that the problem-oriented courseware would result in greater cognitive achievement in microeconomics on the overall measures (i.e., total score on each of the pre, post, and delayed posttests), and on the higher-order and lower-order question subscales. Also, it was believed that problem-oriented instruction would result in greater long-term retention of the conceptual knowledge, while individuals expressing a deep approach towards learning, a more positive attitude towards economics, and lower computer anxiety would perform higher on the cognitive measures of achievement. Finally, previous research in economic education supported the hypothesized higher cognitive achievement performance, and more "sophisticated" and positive attitudes towards economics for male subjects (Lumsden & Scott, 1987).

Major Research Issues

The study examined numerous questions related to the teaching and acquisition of conceptual knowledge in microeconomics via problem-oriented and rule-oriented computer-based instructional strategies on the secondary education level. The ten alternative research hypotheses, while providing a logical structure to the investigation, were not themselves the conceptual focus of the study.

The principal educational problems addressed in the study included the following areas of inquiry:

1) The effect of rule-oriented and problem-oriented strategies on the acquisition and retention of basic conceptual knowledge in microeconomics;

2) The differential effect of the two instructional approaches on learning and cognition as measured by the higher-order and lower-order question levels of the achievement instruments;

3) The relationship between attitude toward economics and economic attitude sophistication in a microeconomics principles lesson unit;

4) The less understood factor of computer-related anxiety in relation to precollege learning from computer-based instruction;

5) Exploratory knowledge into the deep versus surface approach towards learning dichotomy, particularly in relation to instruction in a subject matter unfamiliar to students;

6) The factor of student gender as interrelated to the other research issues stated in this section;

7) The interaction of the factors noted above in relation to learning in a computer-based economics principles unit;

METHODS

An experimental pretest/posttest study design was conceived to empirically explore a complex array of questions and issues related to computer-based instruction in microeconomics. In analyzing the relative efficacy of two alternative instructional strategies (a rule-oriented and a problem-oriented strategy), 155 senior high school students from four Columbus, Ohio secondary schools participated during the final data collection. These two strategies were broadly derived from the competing pedagogical orientations of the respective behavioral and cognitive schools of psychology and learning theory. Two computer-based lesson units, each designed to reflect operational versions of the rule or problem instructional strategy were designed to teach selected microeconomics concepts over an intensive five-day period in microcomputer laboratories located at each of the four site schools. In addition to the treatment variable, gender was also investigated as a factor in both attitudes and learning.

The treatments were delivered in similar self-contained computer laboratories within each school, on Apple IIe microcomputers equipped with either color or monochrome monitors, and with one student assigned per computer workstation. Each rule-oriented and problem-oriented courseware treatment sequence included five full class periods for lesson modules (i.e., including drill, tutorial, and simulation components), in addition to five class periods used for pre and post-instruction data collection procedures.

A battery of cognitive and affective instruments were used to evaluate the differential effects of the courseware treatments on both student achievement and attitudes, including Pretest (r=.50), Posttest I (r=.76) and delayed Posttest II (r=.62) repeated measures. Three parallel-form instruments, composed of equal numbers of higher and lower-order level questions, were constructed from items selected and modified from several nationally-normed tests including the Test of Economic Literacy and the Test of Understanding in College Economics. Categorization of all achievement questions into higher and lower levels, in addition to obtaining content validity and representativeness, was corroborated by a juror of qualified individuals. In addition, the Survey on Economic Attitudes and the Computer Anxiety Index described earlier were used to examine student attitudes towards economics and level of computer anxiety, respectively. The third attitude measure, the Learning Attitude Survey, was developed to investigate the relationship between general approach towards learning and other factors in the study. Item analysis data further supported the reliability of these instruments.

Parallel form cognitive achievement instruments were each systematically developed with moderate to good reliability, strong content validity, and two subscales representing higher-order and lower-order levels of cognitive processing (Bloom et al., 1956). Three existing affective indexes were obtained that measured attitude towards economics (ATE) as a subject, the degree of economic attitude sophistication (EAS) in a general understanding of the market system, and attitude toward computer technology (CAIN) indicating relative level of computer anxiety. A fourth index (DEEP) was developed locally to measure the relative depth of a student's general approach towards new learning tasks and subject matters.

The effect of the rule-oriented and problem-oriented computer-based instructional strategies on teaching microeconomics concepts was investigated using a variety of statistical analytic techniques including the paired t-Test, univariate and factorial analysis of variance, Chi Square, and multiple linear regression. Cognitive achievement was measured with a 34-item multiple-choice pretest, immediate posttest (Posttest I), and a delayed posttest delivered after a two-week interval for retention effects (Posttest II).

The four affective measures (ATE, EAS, CAIN and DEEP) were randomly administered in the pretest phase while all four were included in a questionnaire battery given in the posttest phase. The data on these affective measures were scored using two different coding schemes (a straight 6-point Likert scale and a 16-point certainty estimate scale), although only data derived from the certainty coding scheme was eventually included in the definitive analyses.

Affective Issues

Three areas of interest in the affective domain were investigated in this study: (1) student attitude toward economics; (2) degree of computer anxiety; and (3) student approach or attitude toward learning. Each of these three topics applied six-point Likert-type inventories, and are discussed briefly in the following section.

Attitude Toward Economics

The nationally-normed Survey on Economic Attitudes was used to address this need (Soper & Walstad, 1987). This instrument consists of two subscales, the ATE (i.e., Attitude Toward Economics; $r=.88$), a general attitudinal measure toward economics as a subject area, and the EAS (i.e., Economic Attitude Sophistication; $r=.66$), comprised of statements reflecting views on specific economic issues, and measuring the degree of sophistication in the student's general understanding of the market system. Together, these scales provided a reasonably comprehensive measure of student attitude toward economics.

Computer Anxiety

The nationally-normed Computer Anxiety Index (Maurer, 1983; $r=.94$), a measure of generalized anxiety towards the computer, was applied to investigate collateral problems associated with instructional computer usage. Generally, student populations tend to be positive/normally distributed, indicating a general acceptance and absence of any specific fear of computer technology by the majority of population. A small but significant group of individuals tend to exhibit considerably higher computer anxiety than the norm, however, and so it is valuable to include this factor in computer-based educational research projects.

Attitude Toward Learning

In addition, a special questionnaire, the Learning Attitude Survey;r=.45), was developed locally to measure students' general approach towards learning. A surface approach was characterized by instrumentalism, extrinsic motivation, performing learning tasks as means to other ends, memorization of new material, and student concern over the length of time the learning task would take. A deep approach towards learning was characterized by interest in the material itself, intrinsic motivation, relating new information to previous knowledge, inductive and exploratory reasoning during a learning task, and a personalization of the new knowledge (Biggs & Rihn, 1984). The "deep approach towards learning" subscale proved to be highly reliable (DEEP r=.82), and was used in a broader analysis of attitude-related factors.

Experimental Treatment

Rule-Oriented Lesson Set

In the rule-oriented lesson set, the general instructional sequence used a combined drill and tutorial-based approach, proceeding through the presentation of concepts and questions delivered within the context of explicit expository and inquisitory instruction (Allen, 1986; Merrill, 1983; Merrill & Tennyson, 1977). The strategy consisted of (a) a series of information presentations, (b) rule-recall questions, and (c) rule-example/non-example-instance instructional sequences teaching knowledge of the major principles and concepts in microeconomic theory. Brief review and overview sections began each lesson module to maintain the continuity between lessons. Supply and demand were introduced as the fundamental components of the market system, while equilibrium was presented as the superordinate concept between supply and demand. Subsequent expository and inquisitory sequences required application of the previous content and an increasingly complex set of well-defined economic rules that were both explicitly taught and exemplified throughout the lessons.

A rule as viewed here is a knowledge representation of some event or object (e.g., economic supply) consisting of a name and corresponding definition classifying the behavior or structure of the event or object (Merrill & Tennyson, 1977). Hence the term rule-oriented refers to the technique of (a) employing superordinate and subordinate concept names and definitions presented initially with critical and variable attributes (expository generalities), (b) presenting and contrasting examples and non-examples (expository instances), (c) frequent questioning on the rules and concepts names and definitions (inquisitory generalities, including direct recall questions); and (d) questioning newly encountered examples (inquisitory instances) to augment student understanding concepts within a logical and unambiguous rule hierarchy. Learning the rule definitions thus promotes a deeper understanding of the change relationships of supply, demand, and equilibrium.

The rule-oriented lesson set consisted of the five program diskettes. Following the introduction, the initial concept sequence began. The general instructional sequence followed a consistent series: (a) first, an advanced organizing preview and review segment prepared the learner for the current lesson, (b) the subsequent presentation of a rule name and definition (expository generality; the initial presentation of the definition included the critical and variable attributes of the concept), (c) a recall question on the preceding rule name and definition (inquisitory generality), (d) a set of paired examples and non-examples in tabular form and brief descriptions of an economic situation which served to illustrate and discriminate the rule clearly (expository instance), (e) a question on the preceding material using an example not encountered previously, and (f) a summarizing restatement of the newly acquired concept name and definition. This basic sequence was reiterated throughout each lesson disk. All questions included informing the learner of results and supplying the correct answer if the learner was unsuccessful after the second attempt. A summative review, including the presentation of rule tables listing each previously learned concept and followed by a mastery series of 8-10 questions concluded each lesson.

Problem-Oriented Lesson Set

In the problem-oriented lesson set, the general instructional sequence employed a role-playing simulation of an imaginary business, proceeding through the presentation of concepts and questions embedded within the context of problem scenarios and events. The lesson set consisted of a series of situations emphasizing application and analysis level knowledge of the major principles and change relationships in microeconomic theory. Brief review and overview sections began each lesson module to maintain the continuity between lessons. Equilibrium, the superordinate concept, was presented initially and consistently as a unifying construct between supply and demand. Subsequent problem situations required application of the student's growing knowledge and a specific cognitive strategy: the "Graphic Method." This cognitive strategy was both explicitly taught and repeatedly embedded throughout the lessons to guide students in hypothesis generation and testing concerning changing behavior within the simulated market system. Hence the term problem-oriented refers to the technique of employing problem situations as the core to understanding concepts operationally, and in using a context-specific problem-solving strategy, the Graphic Method, to resolve the problem by predicting the outcome based upon market changes in supply and demand.

The Problem Scenario. The student is placed in the role of the owner and chief executive officer of a new business. At the same time the computer tutor component of the program plays the role of a professional consulting firm (Microbiz Associates) for young companies similar to the one the student is now operating. The idea is broadly to establish a friendly working relationship between the "consulting firm" tutor and the student "manager" in the course of operating the new business successfully.

The student is requested to invent both a product and a company name. The student enters these names into the program and they are subsequently presented within each problem situation, feedback elaboration and remediation segments of that particular courseware program. Various motivational frames appear throughout the lesson to encourage the student manager to become interested in the profit-making capabilities of his or her own business enterprise. The explicit suggestion is made that profit will be enhanced by correct decision-making during the business operation cycle. (each lesson represents a corporate 3-month quarter).

The new company begins in full production of the chosen good or service. The new student manager is periodically presented with simulated electronic mail business reports sent from the Microbiz firm. The content of each report is a simulated problem situation, each describing a set of particular events requiring the immediate attention of the business manager. These on-line reports include text, supply and demand schedules, and graphs of supply and demand curves. The manager is then required to predict the effect of the economic changes in the determinants of supply and demand on the new equilibrium price and quantity of his or her product. At the conclusion of each program, a synthesizing review is presented over the concepts emphasized during the recent "business quarter". At the conclusion of the lesson set, a summative evaluation of student performance in terms of "profit points" is presented.

RESULTS

In summary, several trends can be identified from the results. First, the main effect of treatment was statistically significant in only one case that indicated the marginal superiority of the problem-oriented subjects on the lower-order subscale of Posttest I. Gender main effects on the cognitive performance measures were not found, although several gender-related trends were observed including the consistently superior performance of males on all cognitive variables and a significantly higher ATE reported among the male subjects.

Concerning the measurement of economic attitudes, ATE was positively related to cognitive performance, with superior achievement related to higher ATE. The results generally confirm the findings of Soper & Walstad (1987, 1988) that a moderately positive association exists between the constructs of attitude toward economics and economic attitude sophistication. Moreover, the combination of ATE and EAS appear strongly related to superior cognitive performance only when both are "High". Higher performers have High ATE/High EAS combinations in most cases, while lower performers tend to report Low ATE/High EAS or High ATE/Low EAS.

Concerning the interaction of CAIN and DEEP, another trend appears for: higher performers report Low DEEP/Low Anxiety, while lower performers report High DEEP and High Anxiety and CAIN score is inversely related to cognitive achievement: the lower the computer anxiety reported, the higher/better the cognitive performance (on most measures).

Result Summary

1) Subjects in the problem-oriented treatment group consistently outscored their rule-oriented counterparts on most cognitive outcome measures including the overall score and lower-order subscale score of Posttest I and II, and the higher-order score of Posttest I. This superior cognitive achievement was statistically significant (p = .045) as a main effect only in the lower-order subscale of Posttest I, however.

2) Mean scores of Male subjects were greater than female subjects on all cognitive measures, including the overall score and both higher and lower-order subscale score on Posttest I and II. Importantly, none of these differences was significant.

3) None of the ATE or EAS main effect differences was statistically significant for any cognitive measure including the overall score and both higher and lower-order subscale score on Posttest I and II.

4) A significant disordinal interaction was observed between ATE and EAS on the overall Posttest I score (p = .017). Subjects in the High ATE/High EAS group outscored all other subjects, and this mean difference was greatest between High ATE/High EAS and: (a) the High ATE/Low EAS group (3.00 points) and (b) the Low ATE/High EAS group (2.34 points). Both differences are considered important from a practical perspective.

5) A disordinal interaction between ATE and EAS on the higher-order subscale of Posttest I was observed in which subjects in the High ATE/High EAS group outscored all other groups (p = .022). A similar disordinal interaction between ATE and EAS was also observed in relation to mean performance on the lower-order subscale of Posttest I (p = .045). Again, subjects in the High

ATE/High EAS group outscored all other groups. Greatest difference in mean performance was between the High ATE/High EAS group and the High ATE/Low EAS group (1.20 points), similar to the results for the Posttest I overall and higher-order scores.

6) A disordinal interaction between ATE and EAS was shown in relation to mean performance on the lower-order subscale of Posttest II ($p = .025$). The result in this case was consistent with the other significant interactions noted above in summary paragraphs 4 and 5: subjects in the High ATE/High EAS group outscored all subjects on the lower-order subscale of Posttest II, with the greatest difference in mean performance observed between the High ATE/High EAS group and the Low ATE/High EAS group (1.70 points).

7) No statistically significant differences could be demonstrated for the overall score main effects of the computer anxiety variable (CAIN), although evidence was presented indicating a trend toward superior performance by subjects in the lower anxiety group on the overall performance means of both Posttest I and II. In the case of Posttest I, the difference was 1.32 points; for Posttest II the corresponding difference was 1.18 points.

8) Significant main effects differences were reported for the computer anxiety variable (CAIN) on the higher-order subscale of Posttest I and the lower-order subscale of Posttest II, respectively. The trend for superior performance (1.10 points) by subjects in the Low Anxiety group was observed on the higher-order subscale performance means of Posttest I ($p = .027$). For Posttest II, the difference between High and Low anxiety subjects was significant only for the lower-order subscale means ($p = .063$).

9) No statistically significant differences could be demonstrated for the overall score main effects of the deep approach towards learning variable (DEEP). However, a surprising trend of superior test performance by subjects in the Low DEEP group over subjects in the High DEEP approach group was observed in the overall performance means of both Posttest I and II (1.25 and 0.34 points, respectively).

10) A significant main effect for the deep approach toward learning variable was reported only in the case of the lower-order subscale of Posttest I. Similar to the trend observed in summary paragraph 9, subjects in the Low DEEP group scored higher than their counterparts in the High DEEP group by 0.95 points ($p = .054$).

11) The ordinal interaction of treatment and EAS on the lower-order subscale of Posttest I indicated the superior performance of subjects in the problem-oriented group in both Low and High EAS conditions. The treatment variable (TREAT) here indicated a main effect result ($p = .050$). The largest difference was observed between problem-oriented and rule-oriented subjects on the High EAS level (1.70 points), indicating a potentially beneficial relationship between learners with High EAS and problem-oriented instruction in economics.

12) Results for the disordinal interaction of treatment and EAS on the lower-order subscale of Posttest II are the reverse of the previous finding for Posttest I (See summary paragraph 11 above and also Figures 6 and 7). While the treatment variable was not itself significant (treatment was significant in the Posttest I case), the disordinal interaction between treatment and EAS was much more pronounced (p = .006). The greatest difference between means (1.80 points) was between problem-oriented (7.00 points) and rule-oriented (5.50 points) groups in the Low EAS category. This situation was reversed in the High EAS category with subjects in the rule-oriented group outscoring subjects in the problem-oriented group by 0.80 points.

13) A disordinal interaction was found between level of treatment and CAIN score for the lower-order subscale of Posttest II (p = .023). While subscale mean performance remained relatively consistent across problem-oriented subjects in either High and Low computer anxiety categories, rule-oriented treatment group performance changed noticeably across the Low to High Anxiety dichotomy. Although Low Anxiety subjects in the rule-oriented treatment outscored all groups, their Higher Anxiety rule-oriented counterparts scored considerably lower (1.90 points lower mean score), showing the largest difference between any two groups. Problem-oriented subjects in the High Anxiety group achieved superior performance over the High Anxiety rule-oriented subjects by 1.40 points. The importance of the computer anxiety variable is demonstrated by the main effect result (p = .084).

14) A disordinal interaction of ATE and DEEP on the higher-order subscale of Posttest II was reported (p = .080). While High DEEP subjects outscored all groups, the High DEEP/High ATE subjects scored lower than Low ATE/High DEEP (0.70 points) and High ATE/Low Deep (0.50 points). The largest difference between groups (1.00 point) occurred between the High DEEP and Low DEEP subjects in the Low ATE category.

15) A significant three-way interaction was observed between treatment, ATE and EAS on the higher-order subscale of Posttest II (p = .058). Highest scorers were in the problem-oriented treatment in the High ATE/Low EAS category, while lowest scorers were in the problem-oriented treatment in the Low ATE/Low EAS category (Means = 6.00 and 4.37, respectively). This particular mean difference (1.63 points) suggests that High ATE is more important than EAS as a factor in cognitive performance. However, although High ATE is influential, especially in combination with Low EAS, where EAS is high for both groups, ATE was not as salient on the higher-order questions of Posttest II.

16) Highest scorers on the overall Posttest I mean were male subjects in the High ATE/High EAS category (Mean = 16.95) while lowest scorers were female subjects in the High ATE/Low EAS group (Mean = 12.95). Although this 4-point difference was very significant from a practical view, the gender x ATE x EAS interaction was not statistically significant on the overall Posttest I. The ATE x EAS interaction was

itself significant, however (p = .015). Males and females performed at the same level when both were in the High ATE/Low EAS category. Also, the relationship between higher ATE and High EAS attitudes in economics cognitive achievement was more pronounced in the male subjects.

17) A significant interaction was observed between gender, ATE and EAS on the lower-order subscale of Posttest I (p = .082). Highest scorers (Mean = 9.06) were males reporting Low ATE/Low EAS, while lowest scorers (Mean = 6.91) were males reporting High ATE/Low EAS. This is the converse of the expected relationship and performance outcomes.

18) The three-way interaction of gender x ATE x EAS approached significance on the overall Posttest II score (p = .124). Highest scorers were females in the High ATE/High EAS group (Mean = 12.56), while lowest scorers were females in the Low ATE/High EAS group (Mean = 9.62), a 2.91 point difference. This result supports the role of High ATE in superior retention performance.

19) Although not statistically significant, the interaction of gender, ATE and EAS on the lower-order subscale of Posttest II also corroborated the importance of ATE in relation to cognitive performance outcomes (p = .163). The widest difference was between female subjects in the High ATE/High EAS group and females in the Low ATE/High EAS group (Means = 7.31 and 4.69, respectively).

20) A significant interaction was reported between treatment, computer anxiety and DEEP on the overall Posttest II score (p = .076). Highest scorers were subjects in the rule-oriented treatment group with Low DEEP/Low Anxiety (Mean = 14.00), while lowest scorers were rule-oriented treatment subjects with Low DEEP/High Anxiety (Mean = 10.15), a mean difference of 3.85 points. Treatment groups were closest when rule-oriented treatment subjects were Low DEEP/Low Anxiety and when problem-oriented treatment subjects were Low DEEP/Low Anxiety (Means = 11.14 and 11.25, respectively). This finding supports the importance of the CAIN measure, and the consistent superior cognitive performance in this computer-based study of subjects with lower computer anxiety.

21) A significant interaction was also reported between treatment, computer anxiety and DEEP on the lower-order subscale of Posttest II (p = .076). Highest scorers were subjects in the rule-oriented treatment with Low DEEP/Low Anxiety (Mean = 8.27), while lowest scorers were rule-oriented treatment subjects with Low DEEP/High Anxiety (Mean = 5.15), a mean difference of 3.12 points. In all mean comparisons within the High Anxiety group, the problem-oriented treatment group outscored the rule-oriented treatment subjects, and this superiority was clearest when both treatment groups were in the Low DEEP category (Means = 7.04 and 5.15, respectively). The finding again supports the

importance of the CAIN measure and the consistently superior performance of subjects with lower computer anxiety. The computer anxiety factor, however, appears to have been less salient for subjects in the problem-oriented treatment.

22) A significant three-way interaction was observed between gender, computer anxiety and DEEP on the Posttest I higher-order subscale (p = .052). Highest scorers in this case were males in the High DEEP/Low Anxiety group, while lowest scorers were males in the High DEEP/High Anxiety group (Means = 8.20 and 5.27, respectively). The difference here of 2.93 points corroborates other findings of the value of the CAIN measure. A second important difference was seen between females in the Low DEEP category reporting High Anxiety (Mean = 5.54) and those reporting Low Anxiety Mean = 7.28), a 1.74 mean difference.

23) A significant three-way interaction was observed between gender, computer anxiety and ATE on the Posttest I lower-order subscale (p = .044). Highest scorers in this case were males in the High ATE/Low Anxiety group, while lowest scorers were males in the High ATE/High Anxiety group (Means = 9.13 and 7.14, respectively). This result again demonstrates the salience of the CAIN measures in studies involving computer-based instruction in economics.

24) A series of hierarchical multiple regression analyses were performed. Apart from the inclusion of the treatment variable (p = .045), the DEEP score (p = .046) and to some degree the CAIN score (p = .089) on the lower-order subscale of Posttest I, no other statistically significant regression findings involving the primary independent variables were observed. The application of Pretest and Posttest I variables as regressors was successful on all scales (p = .000 in each case), confirming that (a) the use of pretest scores in the case of an immediate posttest (DV), and (b) both pretest and immediate posttest scores in the case of a delayed posttest (DV) are reliable in explaining the variance of their respective dependent variables.

CONCLUSION

Findings indicate there may be potential benefits of employing problem-oriented strategies in computer courseware teaching basic concepts in microeconomics. While a problem-oriented strategy may not result in a significantly superior level of concept acquisition compared to a conventional rule-oriented strategy, there is evidence that problem-oriented courseware may positively influence student attitude towards economics, as well as students' degree of sophistication towards economic issues about the market system in general. As technology-based problem-oriented environments become increasingly powerful and dynamic, increased benefits in cognitive achievement, and in particular in positive affective changes, may be observed in the long term. However, high-quality rule-oriented strategies, however, are apparently both adequate and equally effective for certain learners (i.e., with a surface approach toward learning) and certain learning tasks with well-defined content domains. The single most "effective" strategy may require some optimal hybrid combination of problem and rule approaches, or other instructional theories and techniques. Future research investigating the application of instructional technologies to secondary content areas should de-emphasize the gross comparison of strategies and short-term outcomes and systematically disaggregate specific individual difference factors in the study of long-term curricular implementation of various instructional strategies.

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Note: Complete ANOVA and regression summary data tables, as well as copies of the instrumentation and microcomputer courseware can be obtained by writing to the author at 2333 Neil Avenue, Columbus, OH 43202.

Title:

Research in Distance Education: Methods and Results

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RESEARCH IN DISTANCE EDUCATION: METHODS AND RESULTS

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ABSTRACT

This paper reports research in progress. The purpose of this study was to examine the growing variety of research emerging in Distance Education and to suggest a method for synthesizing the results. Over 60 articles, representing both quantitative and qualitative studies published in major journals during the past two years, were abstracted and reviewed. Preliminary research categories have been determined and a meta-analytic model has been designed to synthesize the experimental and quasi-experimental data. The remaining qualitative studies will be subjected to a heuristic analysis to present a fuller picture of methods and results of research currently being done in distance education.

BACKGROUND

The theory and practice of learning at a distance is not new. It is a concept which includes all forms of teaching in which the teacher and learner are separated by time and space. Correspondence study, home study and independent study were all early forms of what is referred to today as distance education. However, the past twenty years have shown unprecedented growth in the number of institutions providing distance education throughout the world. In 1971 the United Kingdom Open University, also known as the British Open University, began operation. It was quickly followed within the next ten years by Canada's Athabasca University, China's Television University, Germany's Fernuniversitat , Israel's Everyman's University, Pakistan's Allama Iqbal Open University, and Venezuela's Universidad Nacional Abierta (Rumble & Harry, 1982). The 1980s have seen the establishment of similar open university programs in Thailand, Turkey, Nigeria and many developing countries of the world (McIsaac, Murphy & Demiray, 1988). Recently, more than 700 delegates participated in the 14th World Conference of the International Council for Distance Education, held in Oslo in August 1988. During that conference, major presentations and research reports from over 50 countries were added to the growing body of research in distance education (ICDE, 1988). The increasing number of research articles arriving at the United Nations University International Documentation Centre (Harry, 1988), the recent First American Symposium on Research in Distance Education and the creation in 1987 of the American Journal of Distance Education (Moore, 1987,1988) all reflect the proliferation of documentation and research in this area.

Although research is reported in three or four major journals devoted to the literature in distance education, there has been no effort to centralize research findings. Due to the nature of the endeavor, descriptions of programs, surveys, and experimental studies may be reported at conferences, in government reports, in journals, and in newsletters. Such information is difficult to locate and interpret. This paper reports research in progress relating to one project undertaken to determine emerging research themes and to examine the body of accumulated research concerned with distance education.

A meta-analytic model was designed and a sample of 62 research studies in distance education was selected for preliminary evaluation. Meta-analysis is a technique which quantitatively synthesizes experimental and quasi-experimental research by transforming data to standard scores and reporting effect sizes (Glass, McGaw & Smith, 1981). For this project, research studies which reported non-experimental designs were set aside to be treated descriptively in order to provide a well-rounded picture of what research is saying about distance teaching and learning. The two objectives of the study were to identify research categories which recurred in the literature and to design a model for the data analysis.

METHOD

Seven resources were manually searched for quantitative and qualitative research studies in distance education reported during the two years 1987-89. The sources included ERIC Abstracts, The International Documentation Center Abstracts, The American Journal of Distance Education, The Canadian Journal of Educational Communication, Distance Education, Educational Researcher and the International Council for Distance Education Bulletin . The searches yielded 62 empirical studies which met the criteria established. These were entered into the database. Bibliographies of the previously mentioned studies are currently being searched as well as the American Symposium on Distance Education, Dissertation Abstracts, and Developing Distance Education.

Analysis of the articles revealed two major areas of inquiry with sub-categories in each area. The two major areas were Instruction and Administration. Sub-categories under Instruction included studies which evaluated LEARNING, ATTITUDES, and ATTRITION. Sub-categories under Administration included studies of COST-EFFECTIVENESS and COURSE DESIGN. The largest category of research, LEARNING, reported performance gains, learning styles, learning format, and age and gender differences. The second area, ATTITUDES, reported attitudes and motivation of teachers and students by age and gender. The third sub-category, ATTRITION, included demographics of drop-outs or early-leavers, and provided general student characteristics. Studies under Administration reported in the areas of COST-EFFECTIVENESS, both operating and start-up costs, and COURSEWARE DESIGN, which evaluated the use of print and non-print materials for instruction. Of the 62 articles, approximately half met the criteria for meta-analysis. The remaining studies will be evaluated descriptively to provide additional substantive information about programs and course design.

The second objective of this pilot phase of the project was to design the database and apply a meta-analytic model to one of the identified research categories. In the future, data will be collected and meta-analyses applied to the other identified research areas.

ANALYSIS

The accumulation of research in education offers a challenge to the researcher to synthesize and interpret conflicting results. The systematic approach offered by meta-analysis has been popularized by Glass et al. (1981) and offers a systematic and rigorous approach to standardizing research findings. The recent development of Apple™ Computers' program Hypercard™

offers a user friendly database for conducting the analysis. In this case, the program Hypercard™ was used to automate many of the routine features of the meta-analysis. Hypercard ™ serves three key features in this analysis. First, it provides the format for a database of the surveyed articles. This includes important citation information such as author, title, journal and publisher as well as subject descriptors. Second, each reference is connected to an abstract. Third, each reference is also tied to a stack in which results of the study are reported. Stacks, or series of cards, are being developed to standardize the input of research to allow the researchers to view a concise, clearly articulated summary of the research findings. A complete automation of the computations required to standardize scores for the meta-analysis is currently being developed as an integral part of the results stack.

The type of organization offered by Hypercard™ has many advantages for the researcher. By organizing the studies into information fields, i.e., author, title, etc., it is possible to search or sort by key categories. Easy search of key words is possible within any of the fields, the abstract, or the results. These features can become powerful tools for the scholar.

In the next step, conducting the meta-analysis, the following procedures are used. First, samples are drawn from the available population. The list of sources appears above. Second, information is coded to identify the research categories listed above. Third, statistical computations must be applied to standardize scores and make meaningful comparisons. Results of each study in the form of T- tests, F- tests, Chi Square, correlations and analysis of variance are weighted according to their effect sizes and whether they are truly experimental, quasi-experimental or uncontrolled. The transformation of these statistics results in a common unit or Product Moment Correlation which measures the significance of the research. A correlation of .5 or above and statistical significance of less than .05 is expected if the intervention is to be considered successful. To date, research categories have been determined and the Hypercard™ meta-analytic model designed. The next step is to perform the analysis on the first category, learning.

SUMMARY

This study reports research in progress and the completion of two steps in the synthesis of current distance education research. First, as a result of a review of 62 studies, five research categories were identified as occurring most frequently in current distance education literature. These categories fall under the broad headings of instruction and administration. Next, a model for synthesizing the large volume of recent research was developed using Glass et al.'s (1981) meta-analytic procedures. The model was designed using Hypercard™ as a database to create stacks and link information essential for performing the statistical transformations of data required for a quantitative meta-analysis. The first and largest category of research to be analyzed is that dealing with learning. Meta-analyses of research on attitude and attrition will follow. Descriptive studies of course development and cost-effectiveness will be analyzed qualitatively.

Meta-analysis offers a systematic way to synthesize research in this rapidly growing area of distance education. The development of a Hypercard™ database facilitates data entry and subsequent transformations. It is hoped that the resulting quantitative synthesis of research, identifying which interventions are successful, will provide international distance educators with the necessary information to assist them in developing new strategies for their own programs.

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Title:

Perceived Attidudinal Effects of Various Types of Learner Control in an Interactive Video Lesson

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Perceived Attitudinal Effects of Various Types of Learner Control in an Interactive Video Lesson

Introduction

Areas of Past Learner Control Research

Learner control is traditionally defined as allowing the learner to have some control over the pacing, sequence, or content of an individualized lesson. This type of control is often contrasted with program control, where the flow of a lesson is typically controlled by a computer program. This distinction has also been described as the locus of instructional control (Hannafin, 1984), with the control of instruction being either external (program control) or internal (learner control).

While a number of different research questions are possible within this overall framework, most studies have dealt with differences in achievement based on the availability of instructional control. Such studies have showed both positive results for learner control groups (e.g., Campanizzi, 1978; Fernald, Chiseri, & Lawson, 1975) as well as equal results for learner and program control (e.g., Balson, Manning, Ebner, & Brooks, 1984/85; Mayer, 1976; Reiser & Sullivan, 1977).

Additional research has focused on other factors that relate to achievement for various learner control groups. Studies in this area have included adaptive learner control (e.g., Ross & Rakow, 1981; Tennyson, Park, & Christensen, 1985), learner characteristics that relate to achievement (e.g., Fry, 1972; Gay, 1986), and learner control with advisement (e.g., Hannafin, Garhart, Rieber, & Phillips, 1985; Johansen & Tennyson, 1983). Each of these studies has further defined those factors that can vary the effectiveness of learner or program control.

Finally, student attitudes have been investigated in an attempt to determine systematic attitudinal differences between various types of instructional control. This research emphasis is the focus of the present study.

Past Attitudinal Research with Learner Control

While there have been a number of studies investigating the achievement effects associated with various types of learner control, attitudinal studies have been somewhat limited. The available research in this area can essentially be divided into studies supporting the use of learner control and those studies showing no attitudinal differences between learner control and program (or instructor) control.

Studies supporting learner control. A number of studies supporting the use of learner control have been described by researchers in a variety of content areas. For example, Lahey, Hurlock, and McCann (1973) showed that students preferred student controlled training over programmed controlled by a ratio of 4 to 1 in a basic Naval electronics course. Lahey et. al. (1973) also described the advantages of student control with its active student participation and its simpler lesson design.

In a similar way, Fernald et. al. (1975) found attitudinal results supporting the use of learner control during instruction. In their study, introductory psychology students with control of pacing gave higher course ratings for one out of two courses compared to students following a teacher pace.

Fry (1972) also described college students learning under a high degree of student control as forming the most favorable attitudes toward the method of instruction. Similar results were reported by Newkirk (1973), who showed slightly more favorable attitudes by students with control of sequence. The students with learner control also rated their sequence as less restricting, more sensitive, and more interesting.

Studies not supporting learner control. While the above research showed learner control to be related to more positive attitudes toward learning, other research has not shown such positive ratings. This group of studies has shown learner control to be rated equally with program control of instruction.

For example, Reiser and Sullivan (1977) found no significant attitudinal differences between a group taking quizzes at their own pace and a group using an instructor controlled pace, with pacing procedures well-liked by both groups. Similar results were reported by Judd, Bunderson, and Bessent (1970), who showed a lack of improvement in student attitudes based on increased student control.

In a later synthesis of learner control research, Judd (1972) described finding only a few studies with attitudinal differences supporting learner control although many authors expected this type of control to result in more positive student motivation and attitudes. In another synthesis of earlier research, Merrill (1979) described no consistent increase in attitude toward instruction for groups with learner control.

Method

Design of the Study

The present study used a 2 x 2 factorial design with control of pacing and control of sequence as the two independent variables. The dependent variable was attitude as measured by a post-instruction questionnaire.

The first independent variable, pacing, had two levels -- control by the student or control by the instructional program. The second variable, sequence, also had two levels -- control by the student or control by the instructional program.

The dependent variable (attitude) was measured on an attitudinal instrument developed by the researcher. This instrument was composed of nine Likert-type items and one open-ended request for additional comments.

Subjects

Subjects for the present study included 99 undergraduate volunteers from a Principles of Educational Media course. Participation in this study was one option within the course and involved approximately 75 minutes of each student's time. Each subject received complete oral and written instructions before the instructional program and a written debriefing after their participation ended.

Instructional Materials

Design of the instructional materials. The interactive video lessons designed and produced for this study covered basic 35mm photography knowledge and skills. Specifically, these materials consisted of The Creative Camera optical videodisc (1981) and a computer program written by the researcher entitled "35mm Photography: It's Easier Than You Think."

The overall interactive video program combined visuals and sound from the videodisc and text from the computer. The program was divided into six lessons covering the technical aspects of a 35mm camera, the lenses that may be used with this type of camera, types of available film, effective lighting techniques, proper exposure methods, and photographic accessories.

All instructional materials were pilot tested by subject matter experts in instructional design, photography, and educational software. Additional pilot testing consisted of presenting the instructional materials to twelve undergraduate students of approximately the same age and grade level as the final learners to assess the appropriateness of the materials for these learners, the readability of directions, overall time considerations, and other relevant details.

Learner control options in the materials. The design of these interactive video materials allowed for either program or learner control of pacing as well as program or learner control of sequence. The four treatment groups therefore included: learner control of pacing and sequence, learner control of pacing/ program control of sequence, program control of pacing/learner control of sequence, and program control of pacing and sequence.

Learner control of pacing and sequence allowed learners to control the instructional program as it was viewed. Students in the learner control of pacing groups were able to control pacing by pressing a computer key when finished with each text page. Learner control of sequence was accomplished by allowing students to choose the order of the six lessons to be presented.

Program control of pacing and sequence was carried out by the instructional system without input from the learner. Subjects under program control of pacing saw text screens only for a short period of time, as determined by the amount of text on a given screen. Partially based on the work of Belland, Taylor, Canelos, Dwyer, and Baker (1985), each subject was allowed one second for each line of text on a screen plus thirteen seconds of mental processing time for the passage. All subjects under program control of sequence saw the instructional lessons in a predetermined order (as originally determined by the researcher) and had no control over the sequence of their presentation.

Attitudinal Instrument

Design of the attitudinal instrument. The instrument was composed of nine Likert-scale items and one open-ended question. The same form of this questionnaire was given to all subjects, regardless of treatment group. Questions on the instrument included attitude toward the instructional program, student enjoyment, and beliefs about pacing and sequence. Table 1 shows a list of the Likert items included on this survey. The open-ended question allowed subjects to add any additional comments concerning the instructional program.

Pilot testing of the instrument. Pilot testing of the attitudinal questionnaire was carried out by subject matter experts and learners similar in age to the final subjects. Specific topics in this testing included question readability and content, directions for use, and appropriateness of all questions for each treatment group.

Procedure

All six modules were viewed individually by each student in an area easily accessible by all subjects. Each session included the instructional materials given through the interactive video system and the attitudinal survey instrument.

After the instruction segments had been viewed in their entirety, the subjects were instructed to fill in the attitude questionnaire that they had been given earlier. The data from the questionnaire helped determine students' perceptions of each learner control option and overall attitudes toward the use of interactive video for this instruction.

Results

Results Pertaining to the Likert Items

Table 2 provides the means and standard deviations for all items on the attitudinal survey. For each item, the Likert scale ranged from 1 for strongly disagree to 6 for strongly agree. As can be seen from this table, the data generally showed increased positive attitudes for those groups with learner control.

Table 3 shows the results of a multivariate analysis of variance comparing differences across all items for pacing, sequence, and the interaction between these variables. This table shows sequence to be the only significant factor for this analysis.

Table 4 shows the univariate analyses of variance for each treatment group and their interaction effects. For these analyses, control of pacing was shown to be related to the subjects' perception of the pace of the materials (See Figure 4), with subjects under learner control rating the pace of the program significantly more positively (F=5.64, p=.020, effect size = .48).

Control of sequence was also shown to be a significant factor, related to students' ideas concerning whether this type of control should generally be available in instructional segments (F=13.44, p=.000, effect size = .72) (See Figure 5). This significant relationship indicates that subjects with control of sequence tended to agree with the statement that students overall should be given this type of control.

Results Pertaining to the Open-Ended Question

As part of the attitudinal questionnaire, each subject was also asked for additional comments concerning the instructional program. Of the 99 subjects who completed the survey, 44 answered this additional question, with answers obtained from subjects in all treatment groups. Overall, these comments included comments about the availability of pacing control, concerns about the availability of sequence control, and statements about the effectiveness of the instructional system.

For this open-ended question, students under program control of pacing (where the computer set the pace for the materials), often described the computer screens as too long or the entire program as too slow. Other subjects under program control of pacing described the program as boring or expressed a desire to be able to control the presentation speed. Answers from subjects in the learner control of pacing groups did not include comments about the pace of the program.

In general, subjects made little mention of sequence control in their answers. The comments generally concerned the difficulty of making sequence choices (subjects in learner control groups) and the desire to be able to return to a section for review (learners under program control).

Positive comments concerning the use of interactive video for teaching photography included statements about the high interest level of the materials, the informative nature of the program, and the effective combination of the computer material and the videodisc. Negative comments, however, included a description of the abrupt transitions between the computer and video scenes, a preference for the motion or sound of the videodisc over the textual materials from the computer, and a concern that too much information was presented during the program.

Discussion

Attitudes Toward Learner Control

Overall, the above results support earlier research which has demonstrated mixed effects from attitudinal studies, showing both positive effects from learner control and no change as compared to program control. This combination of effects was shown for both types of learner control (pacing and sequence) investigated in the present study.

Specifically, control of pacing was shown to be significantly associated with students' perceptions concerning the pacing of the materials in the instructional program. This relationship showed higher attitudinal ratings for the pace of the program from those students with pacing control. Answers to the open-ended question also supported this relationship, with a number of negative comments concerning the pace of the instruction from those subjects under program control of pacing.

Control of sequence was also significantly related to one item on the survey, with a relationship shown between this type of control and the students' perceptions that learners should, in general, be able to control the sequence of an instructional segment. For this analysis, the importance of sequence control was rated higher by subjects who had control of sequence in the present study. Analysis of the open-ended question, however, showed little difference between the groups with different types of sequence control.

Specific learner control options were therefore well-liked (or were thought to be important overall) by the subjects in this study. However, this increased positive attitude was not shown by subjects' attitudes toward the overall program, where no statistical differences were shown between the learner and program control groups. Thus, while subjects liked the learner control or thought it to be important, these results were not reflected in more positive perceptions of the overall program by those subjects with learner control.

One reason for this lack of significant differences concerning the overall learning process may have been the previous history of these learners who might have had little opportunity in the past for taking control of their own learning. Learner control might have been threatening to these students since such control typically is not available in most learning situations.

Attitudes Toward the Interactive Video System

Student attitudes toward the use of the interactive video system were consistently high across all groups, with students giving high ratings to the use of the videodisc and generally to the text from the computer. This support was reflected both in the Likert items and the open-ended question.

However, there were no statistical differences concerning the interactive video system based on the type of instructional control. This lack of significance may have been due to potential overriding positive effects from the use of interactive video, which was seen by subjects in all groups as a very effective, pleasing learning environment. In this respect, the use of this medium may have masked any true differences simply because interactive video was significantly different from other types of learning systems previously used by these learners.

Summary

The above results have shown the attitudinal effects of various types of learner control in an interactive video lesson. While general effects were not found, the study did show differences in attitudes toward specific types of instructional control. Further research should identify additional attitudinal items that can be used to better understand differences between learner and program control and the overall use of interactive video.

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Table 1

Attitudinal Questions Answered by Research Subjects

1. I enjoyed learning about 35mm photography with this program.
2. I learned a great deal about 35mm photography with this program.
3. I liked the sequence of the materials in this lesson on 35mm photography.
4. I liked the pacing of the materials in this lesson on 35mm photography.
5. I think students should be able to select the sequence of the materials they are studying.
6. I think students should be able to control the presentation speed of the materials they are studying.
7. I liked the motion segments from the videodisc.
8. I liked the text segments from the computer.
9. I would like to use this interactive video system again if other materials were available.

Likert Scale:

1 = Strongly Disagree 6 = Strongly Agree

Table 2

Means and Standard Deviations of Attitude Survey Items

Item Number	Learner Control		Program Control	
	Pacing	Sequence	Pacing	Sequence
Item 1	4.78 (1.17)	4.80 (1.00)	4.66 (1.14)	4.64 (1.29)
Item 2	4.50 (1.26)	4.51 (1.04)	4.47 (1.10)	4.46 (1.30)
Item 3	4.83 (1.12)	4.63 (1.15)	4.57 (1.12)	4.74 (1.10)
Item 4	4.65 (1.14)	4.45 (1.16)	4.08 (1.21)	4.24 (1.25)
Item 5	4.30 (1.43)	4.73 (1.50)	4.13 (1.59)	3.70 (1.36)
Item 6	5.09 (1.17)	5.04 (1.37)	4.94 (1.29)	4.98 (1.10)
Item 7	5.22 (1.21)	5.22 (1.21)	5.21 (1.12)	5.20 (1.11)
Item 8	4.52 (1.33)	4.47 (1.19)	4.38 (1.13)	4.42 (1.26)
Item 9	5.04 (1.26)	5.00 (1.26)	4.77 (1.22)	4.80 (1.23)

Item 1 = Enjoyed Learning
Item 2 = Learned a Great Deal
Item 3 = Liked the Sequence
Item 4 = Liked the Pace
Item 5 = Students Should Control Sequence
Item 6 = Students Should Control Pace
Item 7 = Liked Motion Segments
Item 8 = Liked Text Segments
Item 9 = Would Like to Use Again

1 = Strongly Disagree

6 = Strongly Agree

Table 3

Multivariate Analyses of Variance of Attitude Survey Items for Type of Pacing and Type of Sequence

Multivariate Tests Using Pillais Criterion

Effect	Value	Exact F	Hypoth. DF	Error DF	Signif
Pacing	.108	1.18	9.00	87.00	.320
Sequence	.175	2.05	9.00	87.00	.043
Pacing by Sequence	.092	.98	9.00	87.00	.461

Table 4

Univariate Analyses of Variance of Attitude Survey

Univariate Tests of Significance for Pacing

Variable	Hyp. SS	Err. SS	Hyp. MS	Err. MS	F	Signif
Item 1	.33	127.17	.33	1.34	.25	.622
Item 2	.02	134.31	.02	1.41	.01	.913
Item 3	1.75	120.20	1.75	1.27	1.38	.243
Item 4	7.91	133.24	7.91	1.40	5.64	.020
Item 5	.37	193.80	.37	2.04	.18	.673
Item 6	.50	143.84	.50	1.51	.33	.568
Item 7	.00	130.49	.00	1.37	.00	.971
Item 8	.50	145.89	.50	1.54	.32	.571
Item 9	1.67	148.23	1.67	1.56	1.07	.304

Univariate Tests of Significance for Sequence

Variable	Hyp. SS	Err. SS	Hyp. MS	Err. MS	F	Signif
Item 1	.71	127.17	.71	1.34	.53	.468
Item 2	.08	134.31	.08	1.41	.06	.812
Item 3	.28	120.20	.28	1.27	.22	.642
Item 4	.77	133.24	.77	1.40	.55	.462
Item 5	27.42	193.80	27.42	2.04	13.44	.000
Item 6	.17	143.84	.17	1.51	.11	.736
Item 7	.02	130.49	.02	1.37	.01	.910
Item 8	.04	145.89	.04	1.54	.03	.866
Item 9	.90	148.23	.90	1.56	.58	.449

Univariate Tests of Significance for Pacing by Sequence

Variable	Hyp. SS	Err. SS	Hyp. MS	Err. MS	F	Signif
Item 1	1.99	127.17	1.99	1.34	1.48	.226
Item 2	.34	134.31	.34	1.41	.24	.627
Item 3	1.07	120.20	1.07	1.27	.84	.361
Item 4	.09	133.24	.09	1.40	.06	.805
Item 5	3.89	193.80	3.89	2.04	1.91	.171
Item 6	4.57	143.84	4.57	3.02	2.46	.086
Item 7	.04	130.49	.04	1.37	.03	.862
Item 8	.00	145.89	.00	1.54	.00	.998
Item 9	.11	148.23	.11	1.56	.07	.794

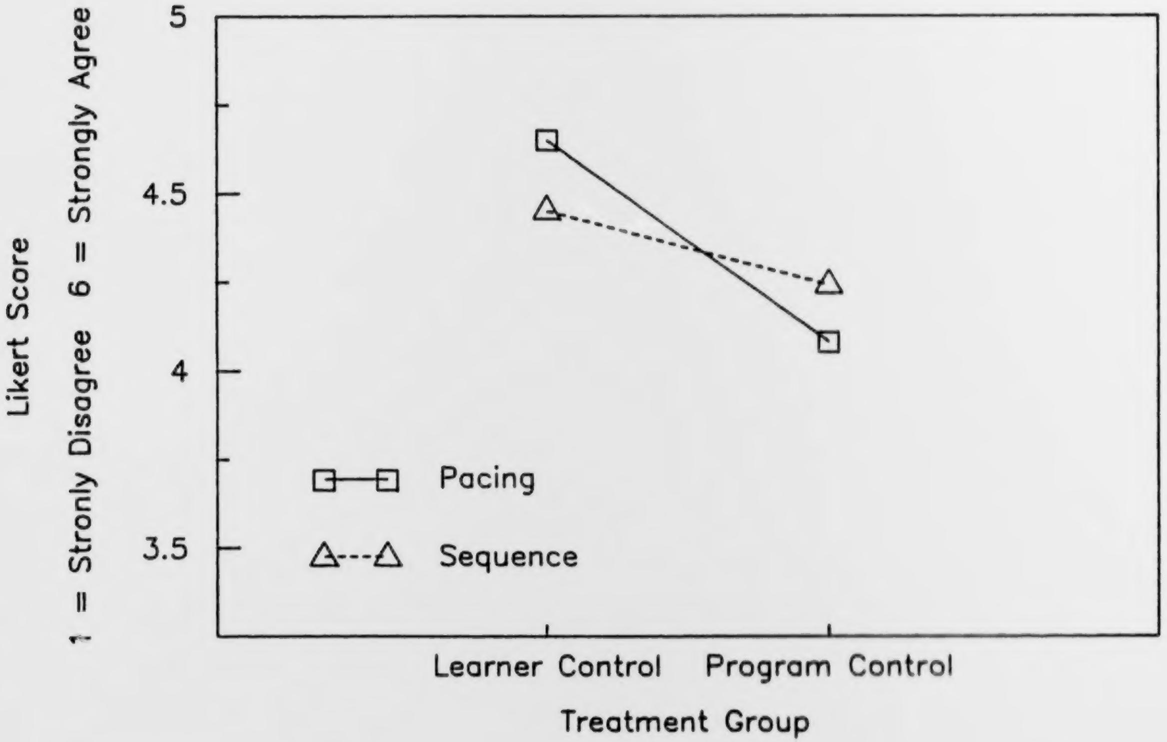

Figure 1. Means on item #4 by treatment group. "I liked the pacing of the materials in this lesson on 35mm photography."

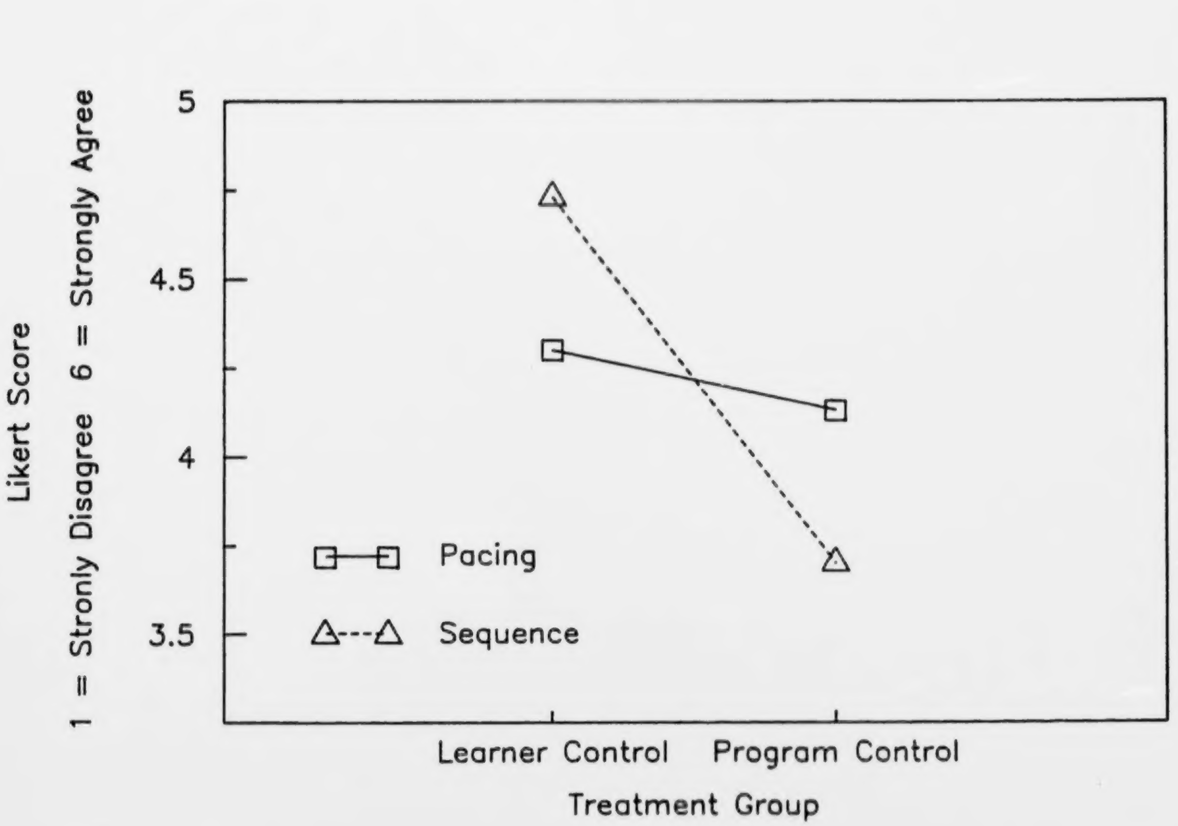

Figure 2. Means on item #5 by treatment group. "I think students should be able to select the sequence of the materials they are studying."

Title:

Reconsidering the Research on CBI Screen Design

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Reconsidering the Research on CBI Screen Design

The continuing expansion of the microcomputer into schools, businesses, hospitals, and homes has created a market for instructional software ranging from beginning mathematics programs to sophisticated simulations of hospital emergency room events. A review of these instructional packages indicates both effective and poor applications of instructional design. One aspect that is often overlooked, however, is the design of screen displays (Bork 1987; Burke, 1981; Keller, 1987). Computer displays (a) are limited to one page at a time, (b) have restricted backward paging and review, (c) are limited to layouts of 40 or 80 columns by 24 rows, (d) provide limited cues as to lesson length, (e) are typically limited to one typeface and one or two typesizes, and (f) offer relatively poor resolution. In contrast to the printed page, however, the computer has the capability to generate dynamic "pages" (e.g., windows, screen building, and animation), which can be increased in number with a relatively smaller effect on distribution costs.

Computer Screen Design

The literature on computer screen design tends to follow one of two approaches. The first approach focuses on typographical variables that the designer can manipulate to create an effective screen design. Based on research and subjective views, several authors have recommended that displays use liberal white space, double spacing, a standard ASCII typeface, and left-justified text (Allessi & Trollip, 1985; Bork, 1987; Grabinger, 1983; Heines, 1984; Hooper & Hannafin, 1986). A second approach to computer screen design is the manipulation of the content. One such method is chunking the material into meaningful thought units which are then presented with blank (white) spaces bordering each. Although Failo and DeBlois (1988) suggest chunking as an effective means of designing displays, research on chunking and similar methods have failed to show clear advantages under either print or CBI (cf. Basset, 1985; Carver, 1970; Fiebel, 1984; Gerrel & Mason, 1983; O'Shea & Sinclair, 1983). It seems important to consider that chunking does not change the instructional content; rather, it changes the way the content is presented on the screen.

This paper will describe two additional variables designers need to consider when designing CBI text screens.

The first variable, text density, manipulates the context of the information presented. The second variable, screen density, is a measurement of the amount of information presented at one time on the screen. The following sections of this paper will summarize two studies on text density and two studies on screen density, and the final section will provide guidelines for designing CBI screen based on these four studies.

Text Density

The research described in this section was designed to identify alternative methods for displaying computer text. Its specific focus was on the level of richness or detail presented in text displays, a variable that we have labeled "density level." In related research with print material, Reder and Anderson (1980; 1982) compared complete chapters from college textbooks to summaries of the main points on both direct and indirect learning. The summaries were found to be comparable or superior in the 10 studies reported. They concluded that the summaries may help the learner focus on the main ideas without the distraction of additional elaborations.

Similar to Reder and Anderson's (1980; 1982) construct, the present text density variable includes such attributes as length of material (number of words), redundancy of ideas, and depth of conceptual support for the main ideas. Reading researchers have referred to such text attributes as "microstructure" (Davidson & Kantor, 1982) or "texture" (Amiron & Jones, 1982). Following Reder and Anderson's (1980) procedure, we generated low-density material from conventional text by: (a) defining a set of rules for shortening the text, (b) having different individuals apply the rules to the rewriting of the text, and (c) requiring those individuals to arrive at a consensus on the final content.

Application of these rules to a textbook unit consisting of 2,123 words on 18 pages yielded a low-density version of 1,189 words (a 56% savings) on 15 pages (a 17% savings). The print pages and computer frames were designed using what were subjectively determined to be the most appropriate layouts for the content. Final versions of the CBI lessons resulted in 49 frames in the low-density lesson and 66 frames in the high-density lesson. Figure 1 shows a sample frame from the two density levels. Although both frames present the same main ideas, the high-density version includes additional elaborations and supporting context.

Insert Figure 1 about here

Our main research interest was evaluating the effectiveness of the low-density material for learning. We hypothesized that, when used in CBI, low-density narrative would promote better learning and more favorable attitudes by reducing reading and cognitive processing demands of the screen displays. A second area of interest was the effect of allowing learners to select preferred density levels in the print and CBI modes. Prior research on learner control (LC) has shown positive results in some studies (Judd, Bunderson, & Bessent, 1970), while more recent findings have been negative (Carrier, Davidson, & Williams, 1985; Fisher, Blackwell, Garcia, & Greene, 1975; Ross & Rakow, 1981; Tennyson, 1980). In contrast to the task variables typically varied through learner control (e.g., lesson length, difficulty, or organization) the text density variable represents a "contextual" lesson property that primarily influences how lesson material appears without changing its basic informational content. Making effective LC choices (i.e., ones that accommodate learning preferences and styles) was therefore assumed to be less dependent relative to these other variables on prior knowledge or skill in the subject area. To investigate these questions concerning density variations and learner control, we conducted the text density studies (Morrison, Ross, & O'Dell, 1988; Ross, Morrison, & O'Dell, 1988), summarized below.

Text Density: Study I

Subjects were 48 undergraduate teacher education majors in six treatment groups arranged by crossing two presentation modes (computer vs. print) by three text density conditions (high, low, and learner control). Main dependent variables were different types of learning achievement (knowledge, calculation, and transfer), and lesson completion time.

Results. The major finding from Study I were

1. No differences in learning occurred between low- and high-density groups.

2. The high-density group, took 34 percent more time to complete the lesson.

3. Within the print mode, low-density text was selected an average of 3.75 (out of 5) times; however, while within the CBI mode, it was selected an average of only 1.25 times, the exact opposite pattern.

4. CBI subjects judged the high-density material as slower moving and low-density material as more sufficient than did the print subjects.

5. Low-performers in the learner control treatment did not seem to favor the "low-support" option (i.e., low-density text) over high support.

Text Density: Study II

Study II (Ross, Morrison, O'Dell, 1988) was designed to extend Study I in several ways. First, comparisons between density and presentation modes were repeated using much larger samples, an immediate achievement posttest, and a delayed achievement posttest. Second, the examination of LC was extended to include selections of both text density ("partial-LC") and presentation mode ("full-LC"). As in Study I, the partial-LC treatment allowed subjects to select either a high-density or low-density text display for each print or CBI lesson. Subjects in the full-LC treatment, however, were allowed to first select either the print or CBI mode, and to then select high-density and low-density text within the selected mode.

Results. The major findings from Study I were

1. Comparisons of the full- vs. partial-LC conditions indicated no significant differences on achievement, attitudes, or density selections.

2. Under CBI, the full-LC group (18.9 min.) took significantly less time than the partial-LC group (29.0 min.), indicating that those who selected CBI completed the lesson more quickly than those who were prescribed CBI.

3. In the full-LC treatment, subjects' choice of presentation mode was almost equally divided between print and CBI.

4. Reading rate was found to be the only significant predictor of these preferences: subjects selecting CBI were faster readers than those who selected print.

5. LC subjects in both groups showed a general tendency to select low-density text (70 vs. 30 percent) more frequently than high-density text regardless of presentation mode.

Discussion

Similar to Study I, the highest achievement scores were obtained by the LC group, but this time the effect was consistent across CBI and print, and statistically significant on three of the four measures (calculation, transfer, and delayed retention). The CBI group (25.8 min.) took significantly more time than the print group (21.5 min.), and the high-density group (26.5 min) took significantly more time than the low-density group (21.0 min).

The significant time savings but comparable achievement using low-density as compared to high-density materials was consistent with the results of Study I. The LC comparisons further suggested that learners are capable of making adaptive decisions when selecting contextual lesson attributes such as presentation mode or text density level. This finding is in contrast to the negative results from LC applications which required learners to select the sequence, difficulty, or amount of instructional support needed to achieve objectives (Hannafin, 1984).

Screen Density as a Design Variable

Prior research on typographical variables and content manipulation have provided useful guidelines for screen design; however, they have not addressed the issue of how much information the expository frame should contain. We call this variable "screen density" as differentiated from text density (Morrison, Ross, & O'Dell, 1988; Ross, Morrison, &O'Dell, 1988) For example, the International Reading Association Computer and Technology Reading Committee (1984) recommends using "clear and legible" displays with "appropriate margins and interline spacing", but provides no operational guidelines or specifications to define these qualities. To provide designers with clearer recommendations for optimum density levels, the screen density construct must be operationalized and precisely defined.

One method of evaluating screen designs is to calculate the density of the total screen by determining how many of the screen spaces are contain a character or are adjacent to a character (Tullis, 1983). Human factors research suggests that performance error rates increase as the density of a display increases (Burns, 1979, Coffey, 1961; Mackworth, 1976; Ringel and Hammer, 1964). Research, however, on the upper limit of screen density has yielded disparate recommendations ranging from 15% (Danchak, 1976) to 31.2% (Smith, 1980, 1981, 1982) all the way to 60% (NASA, 1980).

Another research focus was the possible influence of the type of material presented on how different screen designs were viewed. For example, Grabinger's (1983) evidence for supporting low density screens was obtained using a typographical notation developed by Twyman (1981) to create a content-free screen representation of a CBI screen. In contrast, judgments of realistic materials would appear to demand greater awareness of and reliance on contextual properties (e.g., proximal supporting text) that helps to increase the meaning of the information being read. Thus, it is not clear that preferences for low-density screens similarly apply to realistic lesson materials, especially since the low-density designs present the material in smaller thought units and consequently also necessitate an increased number of lesson frames. We expected that with fixed content and realistic displays, preferences for lower-density screens would not be as high as some of the previous research in the instructional design literature would suggest. A third research interest was the preferences of users differing in degree of CBI experience, namely graduate instructional design students versus undergraduate education students (Ross, Morrison, O'Dell, & Schultz, 1988).

Screen Density: Study I

Subjects were 23 graduate and 23 undergraduate education majors who volunteered to participate in the study. A paired-comparison design (Nunnally, 1967) was employed involving a total of six unique pairings of four density levels presented on an Apple IIe monochrome screen. For each of the six comparisons, subjects were presented with two different screen designs and asked to indicate their preference. The six comparisons and the two density levels within each were presented in a random order.

Results. Table 1 shows the proportion of subjects who selected each density level when paired with each of the alternative levels. These proportions reflect a curvilinear pattern, with preferences tending to favor the two middle density levels (especially the 31% level) over the lowest (22%) and highest (53%) levels. Specifically, the 31% level was favored by the majority of subjects (from 52 to 74 percent) over each of the other three levels; the 26% level was favored by the majority (54 to 56 percent) over each of the two extreme levels.

Insert Table 1 about here

The above results provide information on how the individual density levels were judged relative to one another. A somewhat different question concerns whether or not overall preferences tended to favor, as the literature suggests, lower-density over higher-density designs. However, tabulations across subjects on the six paired-comparison trials indicated the opposite pattern: 156 (57 percent) selections favored the higher density design whereas only 120 (43%) favored the lower density design.

Summary. In contrast to recommendations in the literature (Allessi & Trollip, 1985; Bork, 1984, 1987; Grabinger, 1983; Heines, 1984; Hooper & Hannafin, 1986) for designing lower density screers, these results showed that subjects tended to prefer higher-density screens. The relatively stronger preferences for the 31% (intermediate) density level may suggest that subjects were attempting to balance aesthetic properties (i.e., perceived readability and appeal of the screen) with either both (a) the degree of contextual support and (b) the number of screens in the lesson. If the latter were the key factor, then preferences for the lower density (more spacious) designs would seem likely to increase if judgments were to be based on only the first screen of each screen density level as in Grabinger's (1983) study. Study II was conducted to test this interpretation.

Screen Density: Study II

The primary interest in Study II was to determine replicability of the Study I results when only the first screen of each density level was presented. It was predicted that in this case, stronger preference for the lower density screens would be indicated than in Study I, since reductions in density level would not require having to review a greater number of frames.

Subjects were 27 graduate and 12 undergraduate education majors who volunteered to participate in the study and had not participated in Study I. The same paired-comparison design as in Study I was employed. The stimulus materials were the same as used in Study I with one change. Only the first screen for each density comparison was presented.

Results. The proportion of subjects who selected each density level in the separate comparisons is shown in Table II. Here, in comparison to the curvilinear trend of Study 1, the pattern is directly linear, with the higher-density design consistently preferred over the lower-density design. Across all comparisons, subjects chose the higher-density design 145 (62 percent) times and the lower-density design only 89 (38 percent). Thus, compared to Study I, while no particular density level emerged as significantly more or less desirable than others, there was an even stronger tendency to select higher-density designs in the paired comparisons.

Discussion

Our studies on text density and screen density suggest two additional variables to consider when designing CBI text screens. First, low-density format is a viable alternative to the standard text format used in printed materials. A frame designed with low-density text can incorporate white space, double-spacing, and headings adequately in a single frame. This leaner text format provides the designer with the space needed to organize text which increases its visual appeal (Grabinger, 1985) while minimizing the total number of screens required to present the same content. Ample use of white space, and vertical and horizontal typography with low-density text will typically produce a unit of instruction that is comparable in frame length to high-density text, but with approximately 50% fewer words. The resultant low-density material in our research was read faster, perceived as more sufficient, and selected more frequently under LC than the same text presented in a high-density format.

Second, in contrast to previous studies and recommendations in the instructional design literature (Allessi & Trollip, 1985; Bork, 1984, 1987; Grabinger, 1983; Heines, 1984; Hooper & Hannafin, 1986), subjects indicated a strong preference for learning from high density screens as opposed to low-density screens. These results suggest that the use of realistic stimulus materials may produce different results than obtained with nonrealistic stimulus materials (Grabinger's, 1983) or with informational (e.g., machine status) displays (e.g., Danchak, 1976; Smith, 1980, 1981, 1982). The combined results of the text density studies and and the two screen density studies suggest the use of lean (low-density) text with a medium (31%) screen density. Low-density text provides the designer with a means of reducing the total amount of text in the lesson. The medium density level provides a balance between aesthetic appeal and an appropriate amount of context.

Future research on CBI screen designs should investigate the use of text density and varying screen density with different content areas and tasks with different processing demands. Other research should investigate the application of both low-density text and varying screen densities to online help screens where the purpose is more for review of the ideas as opposed to instruction.

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Table 1

Proportion of Times Density Levels Within Each Paired Comparison Were Selected in Study 1

Paired Comparison											
22%	26%	22%	31%	22%	50%	26%	31%	26%	50%	31%	50%
.46	.54	.26	.74	.46	.54	.35	.65	.56	.44	.52	.48

Table 2

Proportion of Times Density Levels Within Each Paired Comparison Were Selected in Study 2

Paired Comparison											
22%	26%	22%	31%	22%	50%	26%	31%	26%	50%	31%	50%
.28	.72	.41	.59	.44	.56	.36	.64	.41	.59	.39	.62

The median corresponds to the middle frequency score in a ranked set of data

Half the scores will be higher
Half will be lower

X f
Hi 50%
Median------------------------------------
Lo 50%

If N=40 (40 scores), median = 20th score
If N=17, median = 8.5 highest score

Median corresponds to the 50th percentile

Higher than half the scores
Lower than half

The median, another measure of central tendency, is the number that corresponds to the middle frequency (that is, the middle score) in a ranked set of data. The median is the value that divides your distribution in half; half of the scores will be higher than the median, and half will be lower than the median.

X f
Hi 50%
Median------------------------------------
Lo 50%

It is important to remember that the median is the halfway point in the distribution--in terms of frequencies. For example, if N=40 (meaning that you have 40 scores), the median will be your 20th score (in terms of rank); if N=17, the median will be your 8.5 highest score, etc.

Another way of defining the median is to say that it corresponds to the 50th percentile.

In any distribution, the median will always be the score that corresponds to a percentile rank of 50; it is higher than half the scores, and lower than half the scores.

Title:

Reconciling Educational Technology with the Lifeworld: A Study of Habermas' Theory of Communicative Action

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Reconciling Educational Technology With The Lifeworld: A Study of Habermas' Theory of Communicative Action

Introduction

A growing stream of skeptical, even negative criticism about several fundamental aspects of educational technology finds its way through the literature of our field. This criticism sometimes is barely perceptible amid a torrent of technicism nearly everywhere, but it is there. And it considers whether or not the technology isn't fundamentally misconceived, errant, even dangerous.

To cite but one example of this kind of criticism, in The Cultural Dimensions of Educational Computing, C. A. Bowers (1988) studies educational technology and computing and concludes that, "Until teachers reclaim their moral and intellectual responsibilities to students, and educational computing experts recognize that the nontechnical educational issues are the primary ones yet to be addressed, it is likely that the educational use of computers will be driven by the forces of the marketplace and by cultural myths [such as progress and individualism, says Bowers] that put out of focus what we are doing to ourselves and our environment" (p. 115).

It is the purpose of this paper to characterize a selected few criticisms of educational technology that go beyond the technical issues and, then, to offer Habermas' theory of communicative action as way of addressing these criticisms altogether.

Criticisms of Educational Technology

I begin by suggesting four strains of criticism that appear occasionally in literature of educational technology. These four strains are about the following: conceptions of knowledge and its uses, post-positivist philosophy, consequences beyond instruction, and disregard for the metaphysical.

Some authors within the field of educational technology question our fundamental conceptions of knowledge and the uses to which we put that knowledge. For instance, Koetting (1983) looks at the kind of knowledge we in educational technology claim. He describes our technology as a scientific/behavioral model of education that has a constitutive interest in control and certainty (p. 3). He says our "systems approach is based on an empirical-analytic form of inquiry" (p. 4) that focuses almost exclusively on instrumental knowledge. He says further that, "This model is reductive...and oversimplifies its reality....This model does not acknowledge self-reflection (interpretive understanding) or critical analysis....A control model applied to education is an inadequate model when understanding of human behavior and the generation of knowledge is our intent" (p. 17).

Secondly, the questioning of knowledge and its uses includes a line of post-positivistic criticism. I mean post-positivist to be an abandonment of the beliefs that science can explain all human affairs, that something is meaningful only if it is verified empirically, and/or that empiricism or behaviorism are full enough theories of human behavior (See Phillips, 1983, about postpositivism).

Some of this postpositivistic bent appears explicitly in a recent piece by Taylor and Swartz (1988). They write that, "Scientifically generated knowledge...has come under increasing attack. The presumed epistemologically priviledged position of knowledge that results from rigorous application of the scientific method has been deeply--some would say mortally--challenged" (p. 24). They point out that truth and knowledge are made, not discovered by communities of learners and, therefore, "Knowledge from conflicting worldviews will have to be honored" (p. 27) in classrooms. They wonder, "In the future, how will instructional technology respond to the requirements of fluid, multiple knowledge structures negotiated at the local level?" (p. 29).

Thirdly, this examining of knowledge and its uses leads beyond the narrower bounds of instruction and its components. Some of us are looking at any deleterious consequences of our technology in relation to its effects on the likes of personality, society, culture, and the ecology.

I've already noted the work by Bowers (1988) on this criticism. And Apple (1987) studies the socio-cultural implications of educational computing and says there is an increasingly close relationship between school curricula (i.e., knowledge) and corporate needs and that, "the language of efficiency, production, standards, cost-effectiveness, job skills, work discipline, and so on--all defined by powerful groups and always threatening to become the dominant way we think about schooling--has begun to push aside concerns for a democratic curriculum, teacher autonomy, and class, gender, and race equality" (p. 154).

In a fairly recent article, I identified what is the final strain of criticism: formal conceptions of educational technology are too opposed to the metaphysical (Nichols, 1987) in humans.

This last type of criticism is similar to the others in that it acknowledges the positivist nature of educational technology, but it is more general in its claim. Educational technology is not just too behavioral or empirical. It is too extremely rational; it relies too much on human reason generally. Conversely, educational technology is too opposed to the metaphysical, that which is concerned with the broadest classes of reality and knowledge, knowledge which is not tested solely by direct sense observation and which is concerned also with realities such as god, soul, freedom (Randall & Buchler, 1971, p. 102). Educational technologists are not encouraged to be responsible for tacit knowledge, intuitions, or even some forms of expert knowledge (See Dreyfus & Dreyfus, 1984, on expert knowledge). I argue in this article that the extremely rational stance toward existence disengages us from full consciousness and results in personal, societal, and ecological suffering.

Granted, these criticisms do not comprise anything like the bulk of our literature, but they are there. And beyond saying that each in its way questions our conception of knowledge and its application, making the connections among them is very difficult because they may seem so different from one another. What does behavioral psychology have to do with ecological suffering? I believe that Jurgen Habermas' work can help to connect and strengthen some of these criticisms of educational technology.

Habermas' Critical Social Science

Hence, we come to Jurgen Habermas', whose critical theory and theory of communicative action come close to addressing the issues cited above.

First, critical theory is attractive because of its beliefs about positive science. Many in the critical theory school believe that "the all-pervading influence of positivism has resulted in a widespread growth of instrumental rationality and a tendency to see all practical problems as technical issues" (Carr & Kemmis, 1986, p. 130). And as a critical theorist, Habermas wants to develop a critical social science that lies somewhere between philosophy and science. He asks "how can the promise of practical politics--namely of providing practical orientation about what is right and just in a given situation--be redeemed without relinquishing...the rigor of scientific knowledge" (Habermas, 1974, p. 44).

Further, critical theory is based partly in showing how there are several kinds of knowledge. There is objective, instrumental knowledge. There is practical knowledge in which people achieve understanding through language; this is a subjective knowledge. Thirdly, there is emancipatory knowledge in which people may achieve rational autonomy and freedom in intellectual and material conditions via the science of critique and the power that accompanies it. And in this latter kind of knowledge, Habermas may be attempting "to reconcile his recognition of the importance of both 'interpretive' understanding and causal explanations. For example, although Habermas accepts the interpretive insight that social life cannot be explained in terms of generalizations and predictions, he also accepts that the source of subjective meanings lies outside the actions of individuals and, hence, that the intentions of individuals may be socially constrained or redefined by external manipulative agents" (Carr & Kemmis, p. 137).

Perhaps the major criticism of this theory is that it fails to provide rational standards by which it can justify itself, by which it can show itself to be "better" than other theories of knowledge, science, practice. One of Habermas' responses has been to develop the theory of communicative action (Carr & Kemmis, p. 140).

The Lifeworld

Because I believe so strongly that the "other," the elsewise, of rational knowledge has been dangerously dominated by rationalism, I first will deal with that aspect of Habermas' theory of communicative action which addresses this "other." Habermas calls it the "lifeworld." He says of the lifeworld, "It is an implicit knowledge that can not be represented in an infinite number of propositions; it is a holistically structured knowledge, the basic elements of which intrinsically define one another; and it is a knowledge that does not stand at our disposition, inasmuch as we can not make it conscious and place it in doubt as we please" (Habermas, 1981/1984, p. 336). The lifeworld is implicit knowledge that "remains at the backs of participants in communication. It is present to them only in the prereflective form of taken-for-granted background assumptions and naively mastered skills" (Habermas, 1981/1984, p. 334).

Rationality, Communication, and the Lifeworld

Beyond the lifeworld, Habermas describes the rational, which can mean two ways in which knowledge is gathered and used. First, a noncommunicative use of knowledge connotes the successful maintenance or dominance over a contingent, manipulable environment. This is a cognitive-instrumental use of knowledge "that has, through empiricism, deeply marked the self-understanding of the modern era" (Habermas, 1981/1984, p. 10). "On this model rational actions basically have the character of goal-directed, feedback-controlled interventions in the world of existing states of affairs" (Habermas, 1981/1984, p. 12).

The communicative use of knowledge, on the other hand, means communicative competence in the "unconstrained, unifying, consensus-bringing force of argumentative speech" (Habermas, 1981/1984, p. 10). These argumentative speech acts function: to reach understanding with one another and so transmit cultural knowledge, to coordinate social action and so fulfill norms appropriate to a given social context, and to socialize individuals at the level of personality (Habermas, 1981/1987, p. 63).

Speakers fulfill these functions via three kinds of claims in their argumentative speech: they make claims about the truth of their expressions in the objective world (propositional statements in an objective context); they make claims about the rightness, appropriateness, or legitimacy of speech as it relates to shared values and norms in the social world (illocutionary component, normative context); or they make claims about authenticity of speech which is about feelings or intentions (expressive component, subjective context) (Habermas, 1985/1987, p. 312).

The relationships among components of the theory are summarized as follows: "Thus, to the different structural components of the lifeworld (culture, society, personality) there correspond reproduction processes (cultural reproduction, social integration, socialization) based on the different aspects of communicative action (understanding, coordination, sociation), which are rooted in the structural components of speech acts (propositional, illocutionary, expressive). These structural correspondences permit communicative action to perform its different functions and to serve as a suitable medium for the symbolic reproduction of the lifeworld" (Habermas, 1981/1984, p. xxv).

The validity of any claims about truth, rightness, authenticity is tested through argumentation, which does not refer to deductive logic and the connections between semantic units such as you might get with a cognitive-instrumental use of knowledge, but to "nondeductive relations between pragmatic units (speech acts)" (Habermas, 1981/1984, p. 22). There are five kinds of arguments: theoretical discourse, practical discourse, aesthetic criticism, therapeutic critique, explicative discourse (Habermas, 1981/1984, p. 23).

"The rationality inherent in this practice is seen in the fact that a communicatively achieved agreement must be based in the end on reasons. And the rationality of those who participate in this communicative practice is determined by whether, if necessary, they could, under suitable circumstances, provide reasons for their expressions" (Habermas, 1981/1984, p. 17). Suitable conditions require that there is no coercion, but a shared intersubjectivity.

So how are this rational argumentation and the lifeworld related to one another? "The lifeworld is, so to speak, the transcendental site where speaker and hearer meet, where they can reciprocally raise claims that their utterances fit the world, and where they can criticize and confirm those validity claims, settle their disagreements, and arrive at agreements" (Habermas, 1981/1987, p. 126).

Further, "Language and culture are constitutive of the lifeworld itself" (Habermas, 1981/1987, p. 125). When people are in truthful, right, or authentic communication, they use language and culture in such a way that language and culture, too, are implicit, are only on the horizon, are only part of the reservior from which people select knowledge. In their language use, people often attend more to consensus-building than to language and culture themselves.

Rationalization Evolves

In this process of communication, aspects of the lifeworld are made explicit, are rationalized. Structurally, this means that the more culture, society, and personality "get differentiated, the more interaction contexts come under conditions of rationally motivated mutual understanding, that is, consensus formation that rests in the end on the authority of the better argument" (Habermas, 1981/1987, p. 145). This means that normative, value-vested contexts are transferred to rational yes/no positions. The mythic world becomes rationalized. Kinship social structures become bureaucracies. Law and morality emerge from the sacred and become differentiated aspects of society. The notions of a Protestant work ethic and division of labor take hold.

So, as the lifeworld is rationalized, social systems and institutions emerge. Habermas gives this example: "Since the eighteenth century, there has been an increasingly pedagogical approach to child-rearing processes, which has made possible a formal system of education free from the imperative mandates of church and family" [which are less rationalized structures] (1981/1987, p. 147).

As system complexity increases, not only is there a greater reliance on communicative consensus, but the consensus shifts to more and more abstract levels. Take the case of law and morality. "Actors' motives were at first under the control of the concrete value orientation of kinship rules; in the end, the generalization of motives and values goes so far that abstract obedience to law becomes the only normative condition that actors have to meet in formally organized domains of actions' (Habermas, 1981/1987, p. 180).

At the social level, one of the tendencies of this generalization and abstraction is that it "forces the separation of action oriented to success from action oriented to mutual understanding" (Habermas, 1981/1987, p. 180), so systems connected with purposive-rational action, rather than with communicative action, increase.

Media and the Breakdown of Lifeworld and Consensus

As more and more complex social interactions have to be coordinated, mechanisms are developed to reduce the risks and failures in coordinating mutual understanding. Some of the most basic mechanisms are "delinguistified steering media," such as prestige, influence, power, money, and modern electronic mass media. These media coordinate by either condensing or replacing mutual understanding in language (Habermas, 1981/1987, p. 181).

Habermas claims that some media can be successful in helping mutual understanding because they motivate by a trust in knowledge. He says, "Where reputation or moral authority enters in, action coordination has to be brought by means of resources familiar from consensus formation in language. Media of this kind cannot uncouple interaction from the lifeworld context...because they have to make use of the resources of consensus formation in language" (1981/1987, p. 183). Media such as reputation and value commitment "relieve interaction from yes/no positions of criticizable validity claims only in the first instance. They are dependent on technologies of communication [mass media], because these technologies make possible the formation of public spheres...connected up to cultural tradition and, in the last instance, remain dependent on the actions of responsible actors" (Habermas, 1981/1987, p. 185). I suppose a community newspaper that encourages people to argue about political candidates serves as an example of a medium being used for consensus formation.

However, "Media such as money and power attach to empirical ties; they encode a purposive-rational attitude toward calculable amounts of value and make it possible to exert generalized, strategic influence on decisions of other participants while bypassing processes of consensus-oriented communication. Inasmuch as they do not merely simplify linguistic communication, but replace it with a symbolic generalization of rewards and punishments, the lifeworld contexts in which processes of reaching understanding are always embedded are devalued in favor of media-steered interactions; the lifeworld is no longer needed for the coordination of action" (Habermas, 1981/1987, p. 183). Further, delinguistified media such as money and power, connect interactions into more complex networks that no one has to comprehend or be responsible for (Habermas, 1981/1987, p. 184).

"In this way the destruction of urban environments as a result of uncontrolled capitalist growth, or the overbureaucratization of the educational system, can be explained as a 'misuse' of media. Such misuses spring from the false perception of those involved that rational management of steering problems is possible only by way of calculated operations with money and power" (Habermas, 1981/1987, p. 293).

Note that neither the rationalization of the lifeworld nor the increases in system complexity are necessarily a problem. The difficulty is "an eletist splitting off of expert cultures from contexts of communicative action in daily life" (Habermas, 1981/1987, p. 330).

To sum up, in Habermas' words, "The rationalization of the lifeworld can be understood...in terms of successive releases of the potential for rationality in communicative action. Action oriented toward mutual understanding gains more and more independence from normative contexts. At the same time, ever greater demands are made upon this basic medium of everyday language; it gets overloaded in the end and replaced by delinguistified media. When this tendency toward an uncoupling of system and lifeworld is ... depicted on the level of a systematic history of forms of mutual understanding, the irresistable irony of the world-historical process of enlightenment becomes evident: the rationalization of the lifeworld makes possible a heightening of systematic complexity, which becomes so hypertrophied that it unleashes system imperatives that burst the capacity of the lifeworld they instrumentalize (1981/1987, p. 155).

Implications

What do the critical and communicative theories imply for educational technology? What do they say about the criticisms suggested at the beginning of this paper?

Given the analyses of Koetting (1983) and others cited earlier, it is clear that educational technology is in some instances what Habermas describes as a system of purposive-rational action. This is especially the case with instructional development and design. At least it would like to be (See Gagne, 1987, p. 5).

One thing this purposive-rational stance means is that we are helping to rationalize the lifeworld. For instance, as we observe students' perceptions of themselves in relation to the computer, as did Turkle (1984), we are making explicit that which was simply tacit until the coincidence of the computer and the student and until someone decided to look at the relationship, make it conscious. Just to contribute to rationalization is not necessarily good or bad.

But what happens if we examine educational technologists, our processes, and our media as they relate to the fullest kinds of education? And here I am assuming a correspondence between Habermas' aspects of critical social science and communication, on one hand, and education, on the other. That is, I believe education should function, via communicative action, to help us competently reach understanding with one another (the cultural function), fulfill appropriate societal norms (the social function), and develop our personalities (the socialization function), and in the process, learners become involved with objective, practical, and emancipatory forms of knowledge. Given this assumption, we can ask about the extent to which our educational technology encourages these functions with these kinds of knowledge.

From this point of view, we come up short because three of the needs for fulfilling the communicative functions are given too short shrift. Firstly, we do not formally, publicly, admit the existence of a lifeworld. But to Habermas the lifeworld and the rational world are not completely separate. The lifeworld is not an unspeakable human aspect. To exclude formal notice of that in humans which is only implicit is short-sighted and dishonest.

Secondly, some educational technologists conceive of knowledge too narrowly. As pointed out earlier, some of us tend to focus largely on objective knowledge used instrumentally. This is virtually a definition of the field. However, Habermas says that the world, existence, is not simply objective and instrumental. It's not even fully rational. With normative rightness and subjective truthfulness, the world is a relationship of the objective, the social, the subjective, and the aesthetic. Likewise, the world of education and educational technology is normative, subjective, and aesthetic. To the degree that we deny these kinds of knowledge, again, we are being short-sighted and dishonest.

Thirdly, regardless of the kind of knowledge involved, we do not for the most part operate consensually. Ironically, our communications models may best reveal this. If we examine Schramm's adaptation of

Shannon's communication model as it is described by Heinich, Molenda, and Russell (1985, p. 15), we are told that the model emphasizes that communication occurs only where the fields of experience overlap. This overlap would appear to be consensual. Within the overlap, it may be. But the purposes driving the sender's (teacher, instructional designer, adminstrator, society, ect.) messages are not always made known to the receiver (learner); the purposes often lie outside the overlapping experiences. The learner does not always have the chance to come to agreement about them. This is the eletist bypassing of consensus that Habermas refers to. To the degree that the driving reasons are not accessible, education is not consensual but is coercive.

At least implicitly, we can see an example of increased system complexity and bypassing of consensus in Heinich's (1984) statement that "as technology becomes more powerful and more pervasive in effect, consideration of its use must be raised to higher and higher levels of decision making" (p. 77).

Now I won't claim that in every instance our technologies bypass consensus, but I am sure it happens. And I am sure this is really the most powerful of questions we can ask about our technologies: In what cases are our processes and media by-passing consensus which includes the learner?

Taken together, I would say these three kinds of deficits in our technology result in the following kinds of consequences. A good deal of objective knowledge, which functions to keep the status quo about culture and society, is discovered and passed on via educational technology. I have no quarrel with this, as far as it goes. But practical and emanicipatory knowledge gained through consensual communication are not part of our formal conception of educational technology; and to that extent, our technology and the knowledge it manipulates is meaningless to many whom it touches (controls?). I think this meaninglessness is part of the reason educational technology has never been adopted to the extent possible. This is why educational technologists get left out of national reform movements such as The Holmes Group.

And formal conceptions of educational technology have the effect of encouraging social, cultural, and ecological injustices. For instance, schooling and educational technologies help to reproduce the social status quo. Lately this reproducation of a social sort has been argued to be racist, sexist, and classist. Again, I recommend Apple (1986) and Bowers (1988) on these propositions. Though educational technology as you and I know it is certainly not responsible for all these ills, I think we contribute our fair share to them.

Conclusion

You may have noticed that I have used the adjectives "formal" or "public" to describe conceptions of educational technology and technologists. I intend by these to mean that in our everyday conceptions and uses of technology we do not totally omit the lifeworld or consensual communication. We omit these mostly in our formal, public persona. But to the degree that our thinking and uses of technology are influenced by this public display, they may become predominant. And as I have indicated, it's time to be extremely skeptical, perhaps even radical, about predominant conceptions of our technology.

It is time, also, to admit that the lifeworld informs all aspects of what educational technologists do--even during the most supposedly rational of moments, for instance, when we're selecting an instructional strategy. Admitting the lifeworld and admitting we can't know and control all aspects of learning are steps that might be well received because of their openness and honesty. This openness might lead us not only to other, more sensible kinds of knowledge, but to a moral condition in which technology is used more to educate and less to subjugate people and the earth.

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Title:

A Comparison of Three Computer-Generated Feedback Strategies

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A Comparison of Three Computer-Generated Feedback Strategies

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One of the advantages in utilizing computers to facilitate instruction is the ability to provide the student with immediate feedback to convey the correctness or incorrectness of his or her response. If computers are to be used as primary delivery systems in educational and training applications, additional research is necessary to determine which types of feedback are important for student achievement of different educational objectives.

There are numerous kinds of feedback. Feedback cannot be easily defined primarily because a number of theoretical positions are embedded in the concept today (Langer, 1983). Results indicate that all feedback strategies are not equally effective in facilitating student achievement of different educational objectives (Dwyer & Arnold, 1976). However, according to Langer (1983), feedback is considered a critical instructional component by most instructional systems analysts and psychologists.

Feedback can range from a simple knowledge of correct response such as "yes, that's right" or "no, that's wrong" (Travers, Van Wagen, Haygood, & McCormick, 1964) to an elaborate computer-based mechanism that continuously shows students what progress they have made toward mastery of an objective by providing meaningful advice and the appropriate stimuli necessary to obtain it (Tennyson & Buttrey, 1980). Kulhavy (1977) suggests that feedback could be treated as a unitary variable ranging along a continuum from a simple "Yes - No" to the presentation of substantial corrective or remedial information that may extend the response content, or add additional information to it.

Several research studies indicate that the most effective form of feedback is corrective feedback as opposed to positive feedback. Feedback has its greatest effect on high confidence errors (Kulhavy, Yekovich, & Dyer, 1976). Guthrie (1971) found that feedback facilitated learning when it followed incorrect responses and had no effect on learning following correct responses.

Gagne, Wagner, and Rojas (1981) consider that feedback is absolutely essential in designing computer assisted instruction. Tennyson and Buttrey (1980, p. 175) contended, "A learner-controlled condition can be a valuable instructional management system, especially for computer based instruction, if students receive sufficient information about their learning development."

The effectiveness of covert vs. overt learning strategies has produced somewhat mixed results in the literature. This is partially due to the type of learning being investigated and the methods used to produce covert or overt rehearsal. Overt learning strategies engage the learner in some form of outward or physical activity to aid in he encoding of information in long-term memory. Overt rehearsal, by requiring the learner to generate knowledge and/or produce and answer, makes the learner aware of limitations in his understanding (Bransford, 1979). Overt rehearsal, therefore, has the potential to be an effective learning strategy which facilitates retention. Dwyer (1984) discovered that a form of overt rehearsal in which students shaded portions of the human heart resulted in an effective rehearsal strategy to facilitate learning.

However, in non-drill computer lessons requiring a student to make an overt response by typing an answer immediately following feedback, the student learns to type the correct answer without attending to the question paired with the answer (Siegel & Misselt, 1984).

Covert rehearsal deals with internalizing or mentally processing information. Researchers (Bobrow & Bower, 1969; Anderson, Goldberg, and Hidde, 1971: Bransford, 1979; Dwyer, 1984) generally found the covert activity of reading correct statements does not provide for a level of processing activity to be significant. However, the ineffectiveness of the covert activity of reading correct statements does not conclude that all covert methods are ineffective. One of the major problems involved in conducting research on covert rehearsal is determining the extent to which the learner is actually performing the covert rehearsal task.

The utilization of feedback in computer-based instruction is a relatively new area which requires additional research to further enhance the knowledge base in this area. This study attempts to explore this area of computer generated feedback based upon the knowledge gained in both written and computer-based instruction.

METHODS

Subjects

One hundred twenty-six freshman and sophomore college students participated in this study. Volunteer participants represented a variety of academic majors.

Instructional Materials

The instructional materials used in this study consisted of the parts and functions of the human heart developed by Dwyer (1965). The materials included a 2,000 word script which described the parts of the heart and their respective roles in the diastolic and systolic phases and four posttests (drawing, identification, terminology, and comprehension).

Programed instructional booklets developed by Parkhurst (1974) were used as a guide for organizing the heart script into instructional frames. These frames, including the associated graphics, became the basis for the development of an instructional computer program by the author in Pascal for IBM and compatible computers.

The program was self-paced allowing the student to look at a frame until the space bar was pressed. There were 38 instructional frames, all but the first had associated questions requiring a student response and providing feedback.

Instructional Treatments

There were three major instructional treatment groups - simple feedback, covert feedback, and overt feedback. Identical instructional frames consisting of text and a labeled graphic of the heart were presented to each group. Following each instructional frame was a question frame. The treatments differed in the associated feedback frames following the student response to the question.

For example, one frame had a short paragraph which discussed the concept that the lower portion of the heart is called the apex and is the part you feel beating. The heart graphic had a label box with the term APEX inside with a line drawn to the lower portion of the heart.

The associated question presented after the instruction was: The portion of the heart that you feel beating is called the ________. The student was then required to type a response.

Simple feedback consisted of the statement "Your answer is correct." or "Your answer in NOT correct." followed by the correct answer and a computer graphic of the heart with the correct answer displayed as a label. Covert feedback was the same as the first treatment except the graphic of the heart had blank label boxes with time delayed labels allowing the student to make a covert response by visualizing the correct label in his or her mind before it appeared. During overt feedback, students were required to make an overt response by entering the correct answer to the question a second time. The computer program would only accept the correct answer and displayed it letter by letter in the proper position on the graphic as it was typed.

Dependent Measures

Dependent measures were the scores on each of the four posttests. The objective of the drawing test was to evaluate the student ability to construct and/or reproduce items in their appropriate context. The identification test evaluated student ability to identify parts or positions of an object. It consisted of 20 multiple choice items. The terminology test also consisted of 20 multiple choice items and was designed to measure the student's knowledge of specific facts, terms, and definitions. In the 20-item comprehension test, the student was given the location of certain parts of the heart at a particular moment of its functioning, then ask to locate the position of other specified parts of the heart at the same point of time.

Procedure

The 126 participants were randomly assigned to one of the three treatment groups with a group size of 42. Each participant was individually given brief instruction on the physical operation of the computer and the instructional program. Participants then proceeded through the instructional unit at their own pace. The tests were administered to the students as they completed the unit. Subjects completed and returned the drawing test before receiving the identification, terminology, and comprehension tests.

Data Analysis

A one-factor ANOVA was used to analyze scores for each of the 4 tests. A total composite test score consisting of the accumulated scores of the identification, terminology, and comprehension tests was also analyzed.

For all statistical analyses and follow-up tests, alpha was set at the .05 level. If a significant F-ratio was found for the feedback method, the means were tested using the Tukey Wholly Significant Difference Test.

RESULTS

Table 1 contains the means and standard deviations for three feedback groups for each of the tests. Significant differences were found for 3 of the 4 tests and for the total test scores. No significant differences were found for the identification test.

Significant differences were found for the terminology test with F(2,123) = 3.64, p < .05. The comprehension test scores were significant with F(2,123) = 4.81, p = .01. The composite total test scores were also significantly different with F(2,123) = 4.53, p = .01. The greatest significant differences were found for the drawing test with F(2,123) = 13.43, p < .001.

The follow-up tests indicated the covert feedback scores were significantly higher in every test. The simple and overt groups were found to produce equivalent results in the terminology and comprehension tests and for the total test scores. However, the covert and overt group scores were similar for the drawing test and better than the simple feedback group. In summary, the scores were generally the greatest for the covert method and the least for the simple feedback method with the overt method equivalent to the simple method is most cases.

TABLE 1
Mean Scores and Standard Deviations on Posttests

TEST		FEEDBACK GROUP Simple	Covert	Overt	Totals
Identification	Mean	14.7	16.1	14.9	15.2
(N = 42)	SD	3.3	3.0	3.5	3.3
Terminology	Mean	11.6	13.6	11.5	12.2
(N = 42)	SD	4.2	4.0	3.9	4.0
Comprehension	Mean	11.7	14.3	12.3	12.8
(N = 42)	SD	4.2	3.7	3.9	3.9
Total(I+T+C)	Mean	38.0	44.0	38.8	40.3
(N = 42)	SD	10.5	9.2	10.0	9.9
Drawing	Mean	12.6	17.0	15.5	15.0
(N = 42)	SD	4.5	3.4	3.8	3.9

DISCUSSION

The various types of feedback had different effects on the objectives measured by the posttests ranging from the identification test which required a minimal level of learning factual information to the comprehension test that required the students to have a thorough understanding of the heart, its parts, its internal functions, and the simultaneous processes occurring during its phases. The various feedback strategies also had a significant effect on the drawing test which evaluated the student's ability to construct and reproduce items in their appropriate context.

The covert strategy in which subjects viewed unlabeled boxes and attempted to mentally fill in the labels before the actual labels appeared after a time delay, proved to be the most significant method in this study. Past researchers (Bobrow and Bower, 1969; Anderson, Goldberg, and Hidde, 1971; Bransford, 1979; Dwyer, 1984) generally found that covert rehearsal strategies do not provide a level of processing activity to be significant. Their failure to find significant effects may have resulted from the level of covert activity being utilized such as reading statements.

The covert activity in this study differed because the computer focused the subjects attention on the screen by using an unlabeled box as a cueing technique and at the same time challenged the student to visualize the correct answer before it appeared. This additional motivational aspect apparently produced a level of internal processing allowing for significant encoding of information into long-term memory. Another explanation for the success of the covert strategy and the contradiction to previous research was that it was incorrectly named covert when in fact it was an overt strategy. It was highly structured and engaged the subjects in an intense form of mental interaction. In fact, the investigator observed outward physical signs when subjects recalled the correct label in the blank box or failed to mentally fill in the label before the time expired and the label appeared. A truly covert activity such as reading summary statements would not elicit a physical response. The previous research involving covert rehearsal was based on a lesser level of mental activity. If the covert method is renamed as another overt strategy, its strengths would be supported by prior studies which actively engaged the learner in a rehearsal activity.

The overt strategy was less effective than the covert strategy when compared to the simple feedback method. The overt strategy required the student to correctly type the answer to the frame question a second time while it was displayed in the appropriate position on the graphic of the heart. Although overt methods have generally been more effective than covert methods is previous research. The result of this particular strategy supports Siegel and Misselt (1984) who stated in non-drill computer lessons requiring a student to make and overt response by typing an answer immediately following feedback, the student learns to type the correct answer without attending to the question paired with the answer. Typing is a motor skill that does not always require concentration on the item being typed.

The overt strategy was superior to simple feedback but not significantly different from the covert strategy in the drawing test. This may have resulted because subjects were using visual images of the screen to reproduce the heart and locate its components. This activity was independent of utilizing feedback to reinforce or correct answers to the question that were needed to do well in the other tests. Both covert and overt methods were comprised of more elaborate feedback screens to enhance this internal visual model. This could indicate a dual-coding (Paivio, 1971) in which the visual information was more effectively coded than the corresponding verbal information associated with the frame question.

These results emphasize the importance of this type of research for the instructional designer who might otherwise conclude the repetitive typing of correct answers during non-drill lessons would automatically insure increased learning of the content material. Another major finding of this study emphasizes that all methods of computer generated feedback are not equally effective in facilitating student achievement of different educational objectives. However, if properly designed, computer-generated feedback has the potential of being very effective. In practical terms, the instructional designer could gain from the findings of this study and design computer-based instructional software incorporating the idea of time delayed labels. This method could be also applied to primary instruction.

A final point of discussion deals with whether or not methods used in this study were actually feedback. Using a strict definition of feedback as information on the correctness of a response, they were not. However, Kulhavy (1977) suggested that feedback could be treated as a variable ranging along a continuum from a simple "Yes - No" to the presentation of substantial corrective or remedial information that may extend the response content, or add additional information to it. This study used more elaborate methods that prompted students to attend to the feedback. There is a need for further research involving new methods to make computer-generated feedback more effective for the learner.

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Title:

A Review of Animation Research in Computer-Based Instruction

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A Review of Animation Research in Computer-Based Instruction

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A Review of Animation Research in Computer-Based Instruction

Abstract

Although the use of animated visuals is both common and popular among CBI designers, the theoretical and empirical foundations for their use have not been firmly established. Animated visuals represent a subset of instructional visuals, not a distinctive set. For this reason, general conclusions from research on static visuals are thought to extend to animated visuals. However, the extent to which animated visuals represent elaborations or departures from this research is questioned. The purpose of this paper is to review current empirical evidence of the instructional effectiveness of animated visuals as an adjunct or alternate presentation strategy. Current applications of computer animation in instruction are discussed and a taxonomy to aid in prescriptive and evaluative purposes is suggested. The theoretical foundations of animated visuals in the areas of perception and long-term memory are also discussed and a brief summary of static visuals research is presented. Finally, conclusions and prescriptions resulting from this review are presented.

Introduction

Animation is an increasingly popular element in computer-based instruction (CBI) and its use, along with other types of graphics, is often advocated (Bork, 1981; Caldwell, 1980). Even a casual review of the many commercial educational software packages available today demonstrates the popularity of animation among software designers. Unfortunately, animation is often incorporated into a program with the intent to impress rather than instruct the user. Sound and graphics have always been among the most seductive educational aspects of computer technology. Increased hardware capabilities coupled with increasingly literate and sophisticated educational consumers demanding "leading edge" design has the tendency to spur greater amounts of "glitter" in software without serious regard to its instructional effectiveness. Hence, the "glitter" of the technology is often accepted as a substitute to proven worth.

There appears to be two fundamental approaches to designing and evaluating computer-based instruction (CBI) — technocentric design and instructional design. Technocentric design is hardware-centered and is evaluated based on how well the capabilities of the hardware are utilized, whereas instructional design is learner-centered and tries to incorporate sound instructional strategies. It is the major contention of this paper that the design and evaluation of animated visuals should follow an instructional design perspective. Unfortunately, many educators continue to evaluate the effectiveness of animation based on technocentric design principles. This may be because the majority of educators are still functioning at the "familiarization" level of computer technology (Rieber & Welliver, in press) in that they are easily impressed by features of the technology which experts take for granted.

Although inappropriate instructional applications of animation are frequently caused by technocentric attitudes, little guidance has been provided to designers and consumers by researchers and reviewers. Although much research has been done to establish the contexts where static visuals are potentially effective (Dwyer, 1978, for example), little research has been conducted to investigate instructional uses of animation directly or to systematically study what potential differences between static and animated visuals exist. Additionally, the empirical data presently available regarding animated instruction has been inconsistent. A premise of this paper is that animated (or dynamic) visuals represent a subset of instructional visuals, not a distinctive set. Hence, it is expected that guidelines generated from the large body of research on static visuals extend to animated visuals, but do not necessarily fully account for differential effects, if any.

It is suggested that CBI applications of animation serve one or more of the following six functions: 1) Cosmetic; 2) Attention-gaining; 3) Motivation/Reinforcement; 4) Conceptualization; 5) Presentation; and 6) Interactive dynamics. These six functions represent an initial attempt at establishing a taxonomy of the uses of animated visuals in instruction. It should be noted at the onset that this is ***not*** meant to be a media comparison review. The conclusions and prescriptions are directed toward animation, a media attribute, and not toward the computer medium directly, although the contention is made that few other media possess the inherent capabilities to deliver animated instruction across the taxonomy as does the computer. This is consistent with the contentions and arguments presented by Clark (1983) and others (Solomon & Clark, 1977; Solomon & Gardner, 1986) that instructional design, not media, accounts for differentiated learning effects. This discussion is but a first step in determining if animation represents a sufficient (though perhaps not necessary) condition for learning when the learning task is congruent to the attributes of animation.

The purpose of this paper is to review current research investigating the effectiveness of animation as a presentation (adjunct or alternate) strategy. Preceding this review will be a description of the taxonomy. Also, the theoretical framework underlying the potential effects of animation, specifically in the areas of perception and long-term memory retention and retrieval, will be briefly discussed. Additionally, the research and subsequent conclusions of static visual research will be reviewed. Since these related research areas are based on the same theoretical framework, they present a reasonable empirical substitute from which to draw tentative guidelines in the design of animated instruction.

A Taxonomy of Animated Visuals in CBI

In a recent review of instructional pictures, Levie (1987) suggested that motivation and learning are the primary motives to incorporating instructional visuals. In order to help CBI designers integrate animation effectively, more detailed elaborations of these motives are needed. For this reason a six category taxonomy is presented to help classify the uses of animation in CBI: 1) Cosmetic; 2) Attention-gaining; 3) Motivation/Reinforcement; 4) Conceptualization; 5) Presentation; and 6) Interactive dynamics. This taxonomy serves to clarify the instructional (prescriptive and evaluative) purposes of animation. It is possible, and likely, that the instructional intent and result of any one animated visual could be classified across more than one category. It is also very likely that the instructional intent can be entirely different from the instructional result when designers make decisions to include animated visuals based on misinformation, misinterpreted information, or no information.

Cosmetic

This is the only category which has no direct instructional intent. The purpose of animation is merely to make the program more attractive. Examples include special effects during opening titles or screens and are often used to advertise the product's or publisher's name. It is possible for cosmetic uses of animation to also perform an attention-gaining function by presenting an interesting graphic in-between lesson parts to pique attention. However, there are several dangers to using animation for only cosmetic reasons. The learner may not perceive the animation as merely adding to the "decor" of the program, but may perceive it as there for an instructional purpose. This not only detracts the learner's attention for an irrelevant task, but also risks frustrating the student when no instructional link is found, or worse misleads the student in some way. Issues in cosmetic uses of computer graphics appear similar to both static and animated graphics.

Attention-gaining

Just as with static graphics, attention-gaining is an obvious, practical, and rationale use of animation. Attention-gaining is an important initial event of instruction (Gagné, 1985). Animation can be an effective way of arousing and maintaining a learner's attention during CBI. Examples include interesting special effects for transitions between instructional frames or lesson parts. Special screen washes, moving symbols or characters (cartoon or text), animated prompts, such as arrows which direct attention to key words, paragraphs, graphics, or other screen items are still other examples of animated attention-gaining devices. Animated figures offer contrast to a static background, thus bringing the animated figure to prominence, thus amplifying or emphasizing important lesson information (Hannafin & Peck, 1988).

Motivation/Reinforcement

Motivational applications of animation have been used extensively, although perhaps haphazardly, in CBI design. In this context, animation acts as reinforcement or feedback to student responses. Much of the motivating appeal of animated visuals is due to novelty. Unfortunately, novelty effects, though real, are temporary and gradually disappear over time (Clark, 1983). Application of static or animated visuals to reinforce student answers must be made cautiously. Attractive and interesting graphics which occur when a student answers incorrectly may actually reinforce wrong responses. For example, an instructional program on weights and measures available from the Minnesota Educational Computer Corporation (MECC) illustrates, through animation, a gallon pitcher filling a number of quart pitchers. If the student responds that three quarts equal one gallon, then the final quart is spilled onto the floor. If watching milk being spilled onto the floor is more interesting to the student, then only an incorrect response will elicit this reinforcement. The power of computer graphics as a long-term motivational tool designed to increase student perserverance does not have much empirical support (Surber & Leeder, 1988).

Presentation

Using animated graphics as an adjunct or alternate presentation strategy represents the most direct instructional application of animation. This area represents the main body of reported research discussed later. Animation is used in two principal ways. First, it provides an alternative or supplement to text in defining a concept, rule, or procedure. Second, it provides an alternative or supplement to text in providing examples, nonexamples, or elaborations of a concept, rule, or procedure. The apparent processing partnership between appropriate use of visual (eg. static or animated graphics) and verbal (textual) information is the foundation of several theories of long-term memory (Bower, 1972; Paivio, 1979) and is discussed in more detail later. Reed (1985) described this use of animated graphics as a "learning-by-viewing approach" (p. 297-298). An example of this instructional application of animation is depicted in Figure 1. Static or animated graphics used in this manner can be classified as representational, analogical, or arbitrary (Alesandrini, 1984). Representational graphics are those that share a physical resemblance with the thing or concept that the picture stands for. Analogical graphics represent a concept or topic by showing something else and implying a similarity and the learner must be able to recognize the analogy. Arbitrary graphics do not look like the things they represent, but are related in logical ways. Arbitrary pictures include graphs, flowcharts, maps, and tree diagrams. Most of the empirical evidence discussed later involves representational animated graphics.

Insert Figure 1 About Here

Conceptualization

This category defines an application of animation which is closely related to presentation. Here, animation is used to aid a student's conceptual understanding ***without*** providing any new information to the student. This application does not replace or supplement definitions, examples, and/or nonexamples of concepts, rules, or procedures, but rather clarifies relationships through visual means. A good of example of this is the software program, ***The Factory*** (Kosel & Fish, 1983), which is represented in Figure 2. In it students attempt to create or replicate a product. The product starts out in raw material form as a square wafer. The raw material is sent through any number of combinations of punch, stripe, and rotation "machines" which successively alter the product into its final shape. By animating the product through the factory, students see the factory assembly process executed as they designed it. The program's animation does not contribute to the student's knowledge base, but rather provides a concrete representation of the process which involves a potentially complex array of relationships among individual components.

Insert Figure 2 About Here

Animation has a indirect relationship to the learning task when applied in this way. Its effect is very dependent on the learner's prior knowledge of the learning task. Novices, who probably would have difficulty in seeing abstract relationships on their own, would be expected to benefit from animation when used in this context.

Interactive Dynamics

Interactive dynamics represent an instructional application of animation where the role of animation is vital, but difficult to distinguish. In this context, computer animation permits the design of interactive programs in which students learn by discovery and informal hypothesis-testing. The graphics change continuously over time depending on student input, thus acting as a form of instantaneous graphic feedback. This application of animation is what Brown (1983) called "learning-by-doing". Successful examples include simulations, such as piloting an airplane or interacting with a Newtonian particle in a gravity-free/frictionless environment as shown in Figure 3 (diSessa, 1982; White, 1984), and learning musical concepts (Lamb, 1982). Other examples include graphic programming procedures in LOGO where students drive an animated "turtle" on the screen (Papert, 1980). However, it is important that students be able to perceive differences in the graphic feedback, an ability which novices especially have a difficult time attaining (Brown, 1983; Cohen, 1988; White, 1984). Several have indicated the need to structure the interactive dynamic in various ways to offset this deficiency (White, 1984; Rieber, 1988) or to augment such interactions with coaching or other prompts (Reed, 1985). Interactive dynamics represent a use of animation not easily replicated given media other than the computer.

Insert Figure 3 About Here

A Theoretical Framework

Several theoretical frameworks exist to support the contention that animation should be effective. This section describes two theoretical perspectives. First, several perceptual factors are briefly described which help to explain how the illusion of animation is made possible. Second, and more importantly, are current views on how visuals contribute to long-term retention of learned information.

Perceptual Factors

Perception is the process which involves selectively attending to and scanning a given stimulus, interpreting significant details or cues, and finally perceiving some general meaning (Levie, 1987). Visual cognition is the process of how people perceive and remember visual information (Pinker, 1984). Having students perceive meaning from animated visuals relies on tricking them to see something that really is not there. Certain basic perceptual factors help to explain this phenomenon.

Computer animation can be defined as a series of rapidly changing computer screen displays that present the illusion of movement (A. Caraballo, 1985). Animation, whether on computer, film, or otherwise, is not ***real*** motion, but only a representation of motion. Even the most sophisticated computer graphics systems operate on a "draw, erase, change position, draw" repetition to produce animation. When individual, non-moving images are shown collectively at around 16 frames per second, the motion is ***perceived*** as smooth and continous. This is known as ***stroboscopic motion***. When images are shown at a rate of less than 16 frames per second, the motion appears choppy or jumpy. Even the most inexpensive computer systems available today easily match this perceptual requirement for adequate illusions of movement. (Interestingly, a commercially available electronic child's toy called "The Animator" operates at far less than the 16 frames per second level, but seems to readily elicit the movement illusion in children.)

Related to stroboscopic motion, is the ***phi phenomenon***, which is the illusion produced when stationary lights are turned on and off in such a manner that a moving image appears. Examples of this phenomenon include theater marquee lights, Las Vegas casino lights, and scoreboards in sports arenas. The phi phenomenon also accounts for animation produced by the coordination of computer graphic pixels.

Both stroboscopic motion and the phi phenomenon seem to occur because of the Gestalt law of continuity (Rathus, 1987). We tend to perceive a series of points as having unity, and so a series of lights is perceived as a moving object. Motion perception is a part of each individual's schema, or organized network of world knowledge (Norman, 1982), because we live in a dynamic world where very little visual information is truly static (Goldstein, Chance, Hoisington, & Buescher, 1982). Therefore, instruction can easily prompt an individual to ***expect*** motion. Consequently, through top-down mental processing, the individual then "sees" motion in a collection of carefully coordinated ***static*** lights in order to fulfill the expectation.

Long-term memory structures

Humans appear to be particularly adept visual learners (Kobayashi, 1986). The predominant theoretical explanation for this is the dual-coding theory advanced primarily by Paivio (1979, 1986). This theory suggests that there are independent encoding mechanisms, one visual and one verbal. Although competing hypotheses exist, such as those suggesting that all information (visual and verbal) is stored in propositional forms (Pylyshyn, 1981), the dual-coding theory has considerable empirical support. Although we may never fully know the physiological mechanism for visual memory storage, the dual-coding hypothesis probably presents the most useful ***model*** for describing and prescribing visual effects common in instruction (Anderson, 1978).

Paivio's (1979, 1986) dual-coding theory contends that pictures and words activate independent imaginal and verbal codes. Based on this theory, the superiority of pictures over words rests on several key assumptions. The first assumption is that separate coding mechanisms have additive effects, that is, if something is coded in both picture and verbal forms, it is more likely to be remembered than if only coded in one form (Kobayashi, 1986). The second assumption is that the availability of these two coding mechanisms differ in that a picture is more likely to be coded verbally and pictorially than words (Hannafin, 1983). Pictures are often remembered better than words because they are more likely to be encoded redundantly than words. Thus, better recall can be expected due to the availability of two mental representations instead of just one. If one memory trace is lost (whether visual or verbal), the other is still available.

Dual-coding is more likely to occur when the content is highly imageable. Paivio and Csapo (1973) investigated the relative contributions of imaginal and verbal memory codes. Their results indicated that higher recall was produced for pictures than for words under all conditions except when subjects imaged to words. Most of the supportive research shows that words, sentences, and paragraphs that are highly imageable are recalled better than those which are not highly imageable. The learning of concrete concepts precedes the learning of abstract concepts; concrete concepts are stored as images whereas abstract concepts are stored as verbal representations.

Animation, like any graphic, should be expected to aid the recall of verbal information when it serves to precisely illustrate a highly imageable fact, concept, or principle. Predicting learning differences based on using animated graphics ***versus*** static graphics is not as clear. Animated graphics should provide greater elaboration than static graphics when lesson information involves highly imageable facts, concepts, or principles that change over time. Hence, animation's attributes of motion and trajectory are distinguishable from the attributes available from static visuals in aiding mental storage and retrieval (Klein, 1987) in certain contexts. Physics instruction, such as that involving Newtonian mechanics, is a good example of highly imageable lesson content that can be facilitated by graphics displayed over a time continuum. The presentation of animated examples demonstrating a ball being thrown can be stored visually as a concrete example. The rules that govern these forces as well as the application of these rules can then be stored in verbal representations. The animated examples allow a more precise image to be stored as compared to a static graphic using arrows and dotted lines representing the concepts of movement and trajectory.

Static Visuals and Learning

Different reviews of representational pictures in instruction report conflicting conclusions (Alesandrini, 1984; Levie & Lentz, 1982; Pressley, 1977; Samuels, 1970). Researchers studying the effects of pictures in prose learning prior to 1970 concluded that pictures generally did not aid in children's prose learning, and occasionally distracted from the printed text (Braun, 1969; Samuels, 1967, 1970). The distracting effect of pictures was explained by the principle of least effort (Underwood, 1963). According to this principle, when two stimuli are presented, the one which can more easily elicit the correct response is attended. Willows (1978) reported a more recent example of the distracting effect of pictures. Younger, less skilled readers were found to be more suspectible to this interference effect. This research seems to indicate that a fine line often exists between the learning and distracting effects of visuals.

Research conducted since 1970, however, points to the positive effect of pictures in prose learning suggesting that pictures can exert strong positive influences on learning given certain conditions. For example, evidence suggests that children's dependence on pictures decreases with age. As children grow older they become better able to produce their own internal images (Guttmann, Levin, & Pressley, 1977; Pressley, 1977). This evidence suggests the developmental importance of imagery ability. Imagery, like many other cognitive processes, develops over time (Lesgold, Levin, Shimron, & Guttman, 1975; Shimron, 1975). Related research has demonstrated the usefulness of teaching imagery strategies to older children as a learning aid (Lesgold, McCormick, & Golinkoff, 1975; Pressley, 1976).

A review by Levin and Lesgold (1978) reviewed "abundant empirical evidence to document the positive value of pictures" (p. 233). The most important conclusion of their review is that pictures should be highly related or congruent to the textual material; unrelated pictures or too complex pictures are superfluous and may be distracting. Others have offered similar design guidelines based on the conditions under which visuals exert positive effects (see for example, the "ten commands of picture facilitation" offered by Levin, Anglin, & Carney, 1987).

Dwyer (1978) reviewed over 100 studies investigating the use of supplemental pictures as an adjunct learning aid in expository text. The studies investigated the effects of realistic pictures that varied in the amount of detail from highly detailed color photos to simple line drawings. The results suggest that pictures facilitate learning for adults under certain conditions. Sufficient processing time is necessary when using visuals with realistic details. Richly detailed visuals require the learner to attend to and systematically scan the visual in search of essential learning cues. If insufficient time is given, students may actually choose to ignore the visuals and attend to the more familiar, printed text. Therefore, when lessons are externally paced, the most effective visuals contain relatively small amounts of visual detail.

The apparent contradictions concerning the effectiveness of pictures in reading require cautious interpretation. One explanation for why picture superiority effects were largely found *after* 1970 is that the facilitating conditions had been made more clear. Pictures effects, like most other instructional aids, do not generalize to all instructional situations. It is clear that there are contexts where pictures do not facilitate learning due to distraction effects and/or the inability of some readers to shift attention from pictures to text. However, ample contexts exist where pictures appear very useful in facilitating reading achievement. Dominant conclusions drawn from this research are: 1) pictures are superior over words for memory tasks; 2) adding pictures (external or internal) to prose learning facilitates learning assuming that the pictures are congruent to the learning task; 3) children up to about the age of 9 or 10 rely more heavily on externally provided pictures than older children; and 4) children do not automatically or spontaneously form mental images when reading.

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Review of Animation Research

Given the rather ubiquitous presence of animation in educational software, surprisingly few studies have been reported. A variety of non-experimental work has been reported with animation. For example, Margaret Withrow, Project Director of the Research Department of Galludet College, has reported encouraging results using computer animation during language activities for hearing impaired students (Withrow, 1978; 1979). Other uses of computer animation include work in motion perception research (Proffitt & Kaiser, 1986) and testing (Hale, Oakey, Shaw, & Burns, 1985). Empirical studies, though rare, have been reported. The purpose of this section is to briefly summarize research on the effects of computer animation as an adjunct or alternate presentation strategy on learning. Table 1 provides a summary of this review.

Insert Table 1 About Here

One early attempt to investigate systematically the instructional effects of computer graphics was reported by Rigney and Lutz (1975). Forty undergraduate college students participated in a study on the workings of a battery. The study measured learning and attitudinal outcomes. Significant differences were found between groups receiving a verbal presentation versus a pictorial presentation which included animation. Higher scores were reported for the pictorial presentation group on recall tests of knowledge, comprehension, and application. This group also rated the lesson as more attractive. However, the study failed to discriminate between the effects of still graphics and animation. For this reason, it was not possible to attribute the learning gains solely to the use of animation.

King (1975) compared three presentation modes: 1) no graphic (text only); 2) text plus the use of still visuals; and 3) text plus animated visuals. Forty-five Naval training students participated in this study which taught the mathematical concept of the sine-ratio. No significant differences were reported between the three groups. Since the subjects were older and probably had already refined many personal learning strategies their dependence on external imagery was probably nominal. Other problems cited by King were the following: 1) the learning task was not sufficiently difficult (i.e. ceiling effects); 2) the criterial measures were heavily weighted verbally; and 3) the crudeness of the text and graphics displays by the host computer. The use of older subjects is a crucial and perhaps confounding variable for most of the computer animation studies.

Collins, Adams, and Pew (1978) studied an animated application of the SCHOLAR computer-assisted instruction system. Three lesson versions utilizing map features in the teaching of South American geography were compared: 1) interactive map; 2) static labeled map; and 3) an unlabeled map. The interactive map condition consisted of a computer graphic map of South America with blinking dots marking cities. During the tutorial lesson, an interaction between the student and map display was established. Student answers were reinforced appropriately verbally and graphically (with blinking dots). The static labeled map condition used SCHOLAR on a nongraphic terminal, but the student could look at a labeled map. The unlabeled condition was identicial to the previous condition except that the student was given an unlabeled map. The study was conducted in two parts: first with a group of nine high-school students, then replicated with a group of nine university students. Results indicated that the interactive map condition was superior to the labeled map condition, which in turn was superior to the unlabeled map condition. This study indicated differentiated effects of animated over static visuals. However, the instructional intent of the animation appeared to be as an interactive dynamic rather than as an adjunct presentation strategy. The animation was triggered according to on-task student performance. The surprisingly low number of subjects per treatment also warrants cautious interpretation.

Moore, Nawrocki and Simutis (1979) studied the following three presentation modes: 1) text plus schematic representations; 2) text plus line drawings; and 3) text plus animated line drawings. Ninety enlisted military personnel participated in this lesson which involved the psychophysiology of audition. The subjects were tested for retention of facts, terminology, identification, and principles. No significant differences between the three presentation modes were reported. Again, however, methodological anomalies likely weakened the ability to detect differences. Subjects in all treatments were required to answer review questions after each of the four lesson parts: if they could not answer 85% of the questions correctly, they were forced back through the section until attaining the 85% criterion. For this reason, subjects probably reached ceiling levels before taking the posttest. Since only the posttest scores were used in the data analysis, it seems likely that potential lesson variation influences were masked.

J. Caraballo (1985) studied the use of animation using the following four treatment variations: 1) no instruction (used as a control); 2) text only; 3) text plus still visuals; and 4) text plus still and animated visuals. Eighty college seniors and graduate students participated in this study which taught the parts and internal processes of the human heart. Once again, no differences were reported between the text only and the other groups using visuals. The age of the subjects is again cited as a possible source of confounding. Additionally, the lesson locations where the visuals were placed were not systematically derived. It is not possible to determine if the embedded visuals were even needed to support the lesson.

A. Caraballo (1985) studied the following lesson presentations: 1) text only; 2) text plus visuals; and 3) text plus still and animated visuals. A total of 109 college seniors and graduate students participated. The lesson content taught computation of area of geometric shapes. No significant differences between the groups were reported. This study appeared to follow appropriate instructional design procedures: two pilot studies using only the first treatment were conducted to validate the materials and also to determine where additional lesson support was needed. Despite this, there are two factors which may have served to confound the results. First, again, an older population was used as subjects. Second, the instructional result of the animation appeared to be as an aid to conceptual understanding rather than presentation. Animation was used to only indirectly show the relationship between geometric shapes as an aid in computing area. Geometric shapes were moved on the screen to show their relationships. For example, two identical triangles were animated to demonstrate how they form a parallelogram. Generally, most college seniors and graduate students would know or remember these relationships with little prompting. For this reason, the addition of animation probably had nominal effect on overall achievement.

Reed (1985) conducted a series of four experiments investigating graphics conditions in the teaching of a variety of algebra word problems. The design of the four experiments followed an iterative process where results of the first experiment were used to improve the instructional delivery in the second experiment, and so on. Different groups of 30 undergraduates participated in each of the first three experiments and in each of the three conditions compared in experiment 4 (for a total of 180 subjects). Experiment 4, studied the final modified lesson across three conditions and across four word problem types (average-speed problems, tank problems, mixture problems). The experimental conditions for each word problem type depended on the results from experiments 1-3. Several hypotheses were tested, including effects of feedback and graphics. Results were mixed according to the word problem task. Student performance on the mixture problems did not depend on the availability of graphics, whereas graphics effects were found for tank problems, but only when paired with the additional strategy of requiring students to make estimations. These results suggest the inability of students who are novices in the content to accurately perceive differences in animated graphic presentations when only required to view the graphic presentation. More accurate perceptions were elicited when the graphic representation was coupled with an instructional strategy which required learners to attend more to the information contained in the graphic.

Rieber and Hannafin (1988) investigated computer animation as an orienting aid during instruction. This study differs from the previous studies in two important ways. First, the previous studies used an older population. College-aged students probably do not benefit from instruction which contains additional visual elaborations since they are able to form mental images without additional lesson support. The Rieber and Hannafin study investigated animation using 111 fourth, fifth, and sixth grade students — a sample from a population expected to benefit more from visual elaborations than adults. The second major difference concerns the role played by animation in the lessons. The potential of animation to support lesson material in previous studies was limited in that motion and trajectory were not necessarily criterion aspects of the content to be learned. This study used animation on the basis of its appropriateness or congruency to the criterion tasks. The lesson content taught Newtonian physics by presenting a simplified account of Newton's laws of motion. Each lesson part was preceded by one of the following four types of orienting activities: 1) text only; 2) animation only; 3) text plus animation; and 4) no orienting activity (control). No significant differences were reported among the four treatments. They reported that the nonsignificant differences may have been due, at least in part, to the general ineffectiveness of orienting activities as an influence on learning (as suggested in other research such as Hannafin, Phillips, Rieber, & Garhart, 1987).

Rieber (in press) followed-up this research to investigate the effectiveness of animation when part of the primary presentation of relevant content. In this study, visual elaborations of the laws of motion content used in the Rieber and Hannafin (1988) study were embedded throughout the lesson. The placement of these embedded visual elaborations were determined by two pilot studies using an all-text version of the content. Student deficiencies in meeting the objectives tested in the posttest were traced back to the lesson presentation and then strengthened with the embedded visual elaborations in the main experiment. The main experiment studied the crossed effects of graphic (static, animated) and textual (text, no text) embedded lesson elaborations and practice (relevant, irrelevant) on factual and application learning of 192 elementary school students. Relevant practice consisted of asking traditional multiple-choice questions after each of the four lesson parts. No significant differences were found among the groups. Several explanations were suggested. First, the students apparently found the lesson content exceedingly demanding which may have served to confound the results. Second, a follow-up analysis of the time spent by student viewing lesson frames containing embedded visual elaborations suggested that students may not have adequately attended to the visuals.

Rieber, (1988) replicated the previous study with several modifications. First, the lesson difficulty in terms of factual and concept density was reduced. Second, the method used to display lesson information was changed in order to better cue students as to what to select and attend to in the lesson. In the Rieber (in press) study, an entire frame was presented to the student at a time with student able to trigger the next frame by pressing the space bar. In the Rieber (1988) study, each frame was broken down into textual and graphic "chunks". Rather than presenting an entire frame of information at a time, each student viewed only a portion of the frame at a time, pressing the space bar when ready to view the next portion or "chunk". This procedural change was most dramatic in the presentation of animated information. Students' attention was more easily directed to and less likely to be distracted away from the animated presentation. Practice was also studied in the form of traditional questioning techniques but also as dynamic interactions consisting of levels of a structured simulation. Results indicated the animated graphic group was superior to both the static graphic and no graphic groups. Also, students in the interactive dynamic practice group outperformed the no practice control group whereas the question practice group did not. An interesting interaction was found between the visual elaboration and practice factors. The animation effect was eliminated without any form of practice. Practice, of either type, seemed to direct students' attention to relevant details in the tutorial. Another interesting finding was animation's influence on incidental learning. The animation group saw a graphic example of Newton's second law. In one frame, graphics of a small ball and a large brick were given equally strong kicks. The acceleration experienced by the ball was dramatically greater than the brick. Although no formal attempt was made to teach this rule, this group seemed to learn this application of Newton's second law based solely on viewing this one frame.

Rieber, Boyce, and Assah (1988) replicated the Rieber (1988) study with 141 adult learners. The purpose of this study was to investigate whether the animation effects on young children would be replicated with adults. The same lesson content was used, but was extensively modified for the adult group. No differences were reported between the visual elaboration conditions on the performance measure. This is consistent with previous research using adult subjects. However, an analysis of subjects' response latency on the posttest indicated that subjects in the animated visual condition took significantly less time to answer posttest questions than subjects in either of the other visual conditions. Thus, the animated visual presentations appeared to aid subjects in the reconstruction process during retrieval. Also, a moderate interaction between the visualization and the practice factors was noted. This interaction indicated the trend that the static graphic and no graphic groups were influenced more by practice than the animated graphics groups. This implies that subjects in the animated graphics group did not require the additional elaboration and rehearsal contained in the practice as much as subjects in the static graphics and no graphics groups.

A variety of other related research has been reported. Riding and Tite (1985) found that computer generated animated visuals effectively prompted nursery school subjects to generate original stories as compared to static visuals and a control condition. Many non-computer studies, involving primarily video, have been conducted over the past 25 years. Spangenberg (1973), for example, taught and tested procedural learning skills (the disassembly of a machine gun) with adults. He found motion sequences superior to stills but this effect was eliminated when the stills condition was revised and retested (in other words, the instructional design was improved). Blake (1977) used static and animated arrows in video instruction to cue subjects' attention to the movement of chess pieces. This study controlled for spatial aptitude of subjects and found that subjects of low spatial aptitude benefited from motion sequences whereas no effect was found for subjects with high spatial aptitude. Finally, Goldstein, Chance, Hoisington, and Buescher (1982) found that subjects' recognition memory was superior for dynamic video scenes as compared to static video scenes from selected excerpts of Hollywood movies. (See Chu & Schramm, 1979 for a further review of early motion studies in television research.)

Summary

Frequently, results from the King (1975) and Moore, Nawrocki, and Simutis (1979) studies are cited as conclusive evidence that animated instruction is ineffective. Clearly, these two studies hardly represent sufficient research data to support such a conclusion. Some of the reported research hints at contexts where animation has at least some empirical support with certain populations. Children's learning of certain science concepts when the difficulty level is matched with ability is one example. The effect of animation on incidental learning also warrants further study. Other research (e.g. A. Caraballo, 1985; Collins, Adams, & Pew, 1978) which studied animation as an interactive dynamic or as an aid to conceptual understanding, where differentiated effects of animation are difficult to distinguish, perhaps present more questions than they answer.

Conclusions and Prescriptions

Guidance in the application of computer animation in instruction is needed, especially as the technology continues to evolve and expand to include such things as three-dimensional animation (Zavotka, 1987). The following conclusions and prescriptions are not meant to represent the final word on instructional applications of animation, but as temporary assistance to practitioners. Additionally, it is hoped that these will act as a catalyst for more research and discussion.

Little research exists which has studied animation systematically apart from static visuals. One obvious conclusion from the several studies reviewed here is that the pool of available animated visual research is generally small. Additionally, several of the reported studies failed to systematically investigate the relative unique contribution of animation as compared to static visuals. That is, the unique instructional contribution of animated visuals is still largely unsubstantiated. Clearly more research is needed.

In general, animation has not proven to be an effective or reliable presentation strategy when considered or studied separately in controlled experiments; any effects, if real, are subtle. This is the issue of efficacy. Animation does not appear to be a powerful influencer on learning. Effects attributable to animation, if any, are perhaps dependant on other lesson components, such as lesson organization or practice. For example, the Rieber (1988) study indicated an interaction between animation and practice such that animation was only effective when moderate amounts of practice were also provided. Those who design lessons which follow poor instructional designs can expect little from additional special effects (like animation) and instead should probably expect detrimental effects, like distraction.

The instructional intent of animation should be based on the instructional result desired. Perhaps this akin to beating the proverbial dead horse, but it should be clear by now that there are many ways in which animated visuals can be used. Haphazard integration of animation can lead to a variety of instructional outcomes, not all of which are positive. Designers should carefully consider their instructional intent and how closely it will influence the desired instructional result. The taxonomy of instructional applications of animation was offered as a guide in this process.

Animation should be incorporated only when its attributes are congruent to the learning task, otherwise, distraction effects may result. If the demands of the learning task involve the attributes of visualization, motion, and trajectory, such as many objectives in science education, then a supporting rationale exists for incorporating animation. If these attributes do not contribute to the learning task, then the learner may be distracted by their presence.

Evidence suggests that when learners are novices in the content area, they may not know how to attend to relevant cues or details provided by animation. Details provided in animation that experts see as obvious or clear may be completely overlooked by novices. That is, the learners may be unable to "read" animated visuals nor be able to integrate with verbal descriptions (cf. Rieber, 1988; White, 1984). This is especially important to note when instruction is designed by a content expert, as is frequently the case. Care should be taken to deliberately cue the learner to watch for the details in the animation which are most relevant (eg. changes in speed and/or direction).

Some aptitude by treatment interactions (ATI's) between learner maturation and spatial aptitude and animation suggest favoring the use of animation in certain cases. Although virtually no specific instructional animation research on this point is available (an exception includes Blake, 1977), several ATI recommendations can be extrapolated from general research. Research indicates that internal mental imagery is developmental in nature. Young children are less likely and less capable than adults to form internal mental images spontaneously. Additionally, individual differences exist in overall spatial ability. Therefore, when the attributes of the learning task are congruent to the attributes of animation, young children and other individuals who possess less spatial ability should particularly benefit from the use of these visuals.

More dramatic benefits of animation may lie in its contributions to CBI applications such as interactive dynamics. Many reported studies suggest that animation's greatest potential may lie in its use as an interactive dynamic. Unfortunately however, it may not be possible to adequately partial out animation's distinguishable role when used in this way. That is, interactive dynamics represent highly sophisticated and complex exchanges or "transactions" between the student and the instruction which cannot be broken down easily into its representative parts, which includes for example, animation. However, the fact that these instructional transactions would not be possible without animation attests to its utility in this area.

Instructional design and learning theory should drive the use of animated visuals, and not simply what the hardware is capable of doing. Technical abilities of hardware and programmers, in and of themselves, have no bearing on their potential instructional effectiveness. The fact that animation ***is*** an option does not mean that it ***should*** be an option. CBI designers are faced with a curious dilemma. They must resist incorporating special effects, like animation, when no rationale exists, yet must try to educe creative and innovative applications from the computer medium. Instructional design still represents the recommended process for identifying instructional problems and then designing, developing, and evaluating instructional solutions on the computer or with other emerging technologies, such as interactive video and hypermedia (Hannafin & Rieber, in press).

Closing

The general failure of animation to impact learning empirically contrasts the theoretical bases (in mental imagery and visualization) which support it. However, general procedural flaws in several of the animation studies, as well as a lack of generality of results, make interpretation inconclusive. If animation is an effective instructional element, its influence is probably not as evident in the presence of well-designed and organized instruction. Its influence, like many other instructional aids, may be weakened in the presence of more powerful lesson elements (cf. Mayer, 1979). In addition, the effects of animation could be dependent on content and learning task variables.

Designers and consumers of educational software and emerging technologies should approach instructional uses of animation with caution. The few serious attempts to study the instructional attributes of animation have not adequately shown it to be effective. Although it is expected that the conditions under which animation is effective will eventually be empirically derived, adequate and accurate prescriptions, beyond the general ones already described, are not available. It could be that the discrepancy of expected results and empirical evidence demonstrates a failure on the part of researchers, rather than inappropriate applications on the part of designers and instructors. Research from related areas should serve to guide educators until more specific research data is available. For example, the potential for animation to distract learners should be noted. Related research has also indicated that developmental factors may be involved. Also, the way learners perceive animation could also have an effect on learning. Research suggests that there are optimal levels of motivation and arousal for many instructional components. When learners perceive components as requiring too little or too much effort, there is a tendency for them not to attend to the instruction appropriately (Salomon, 1983).

The research effort in static visuals represents perhaps a curious analogy to the current research in animation. Research prior to 1970 largely concluded that adjunct visuals either had no effect or negative effects on learning. Fortunately, research did not stop based on this conclusion. It took more time coupled with a systematic effort to finally describe the ***conditions*** under which static visuals could be used effectively to promote learning (Merrill & Bunderson, 1981) and it is only recently that this research base has started to be effectively applied to instructional computer graphics (Alesandrini, 1987). It is suggested that research into animated visuals will require a similar systematic process and effort to uncover unique conditions.

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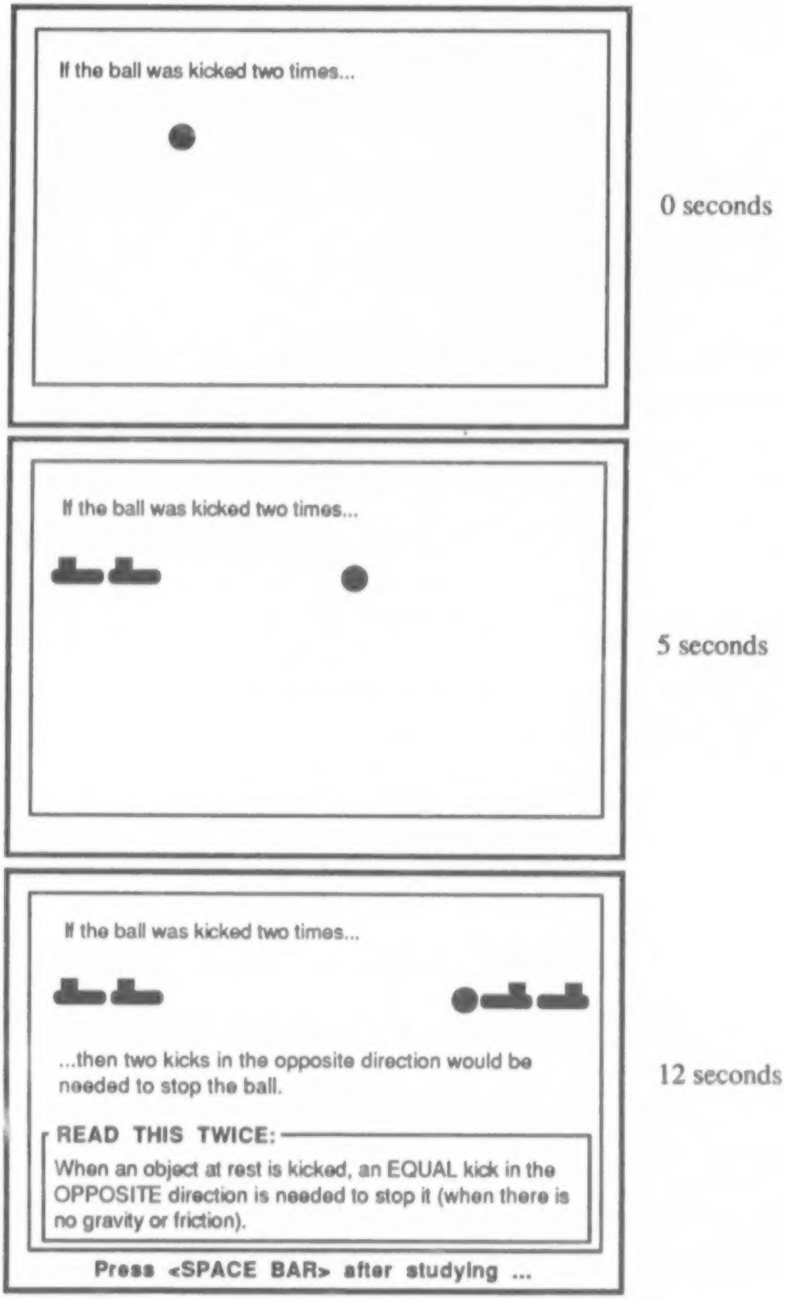
Table 1

Summary of Empirical Research Studying the Instructional Effects of Animation

Study	Subjects #	 Age	Content	Results Regarding Animation	Comments
Rigney & Lutz, 1975	40	Adult	Science: How a battery works	Higher recall for pictorial group	No control for static vs. animated visuals
King, 1975	45	Adult	Math: sine ratio	NSD	Learning task not sufficiently difficult
Collins, Adams, & Pew, 1978	18	Adult	Geography of South America	Interactive Map> Labeled Map> Unlabeled Map	Animation used as an interactive dynamic, not as an elaboration of lesson content
Moore, Nawrocki, & Simutis, 1979	90	Adult	Psychophysiology of audition	NSD	Confounding due to instructional design: review was automatically given to students after each lesson part if achievement less than 85% thus producing a ceiling effect
Caraballo, J., 1985	109	Adult	Physiology of human heart	NSD	No validation done to determine if additional visuals were needed
Caraballo, A., 1985	109	Adult	Computation of area of geometric shapes	NSD	Animation used as an aid to conceptual understanding, not as an elaboration of lesson content
Reed, 1985	180	Adult	Algebra word problems	Mixed according to word problem type	Lessons were iteratively improved over 4 experiments; Animation effective when replacing rather than supplementing verbal info
Rieber & Hannafin, (1988)	111	Children (elem.)	Newton's laws of motion	NSD	Animation studied in context of orienting activity; possible confounding due to lesson difficulty
Rieber, in press	192	Children (elem.)	Newton's laws of motion	NSD	Possible confounding due to lesson difficulty
Rieber, 1988	119	Children (elem.)	Newton's laws of motion	Animation>Static=None; Interaction between visuals & practice	Animated visuals contribution distinguishable from static visuals; animation most effective when practice support was moderate; moderate animation effect in promoting incidental



If the ball was kicked two times...

If the ball was kicked two times...

If the ball was kicked two times...

...then two kicks in the opposite direction would be needed to stop the ball.

READ THIS TWICE:

When an object at rest is kicked, an EQUAL kick in the OPPOSITE direction is needed to stop it (when there is no gravity or friction).

Press <SPACE BAR> after studying ...

Figure 1. An example of using animation as an adjunct presentation strategy in science.

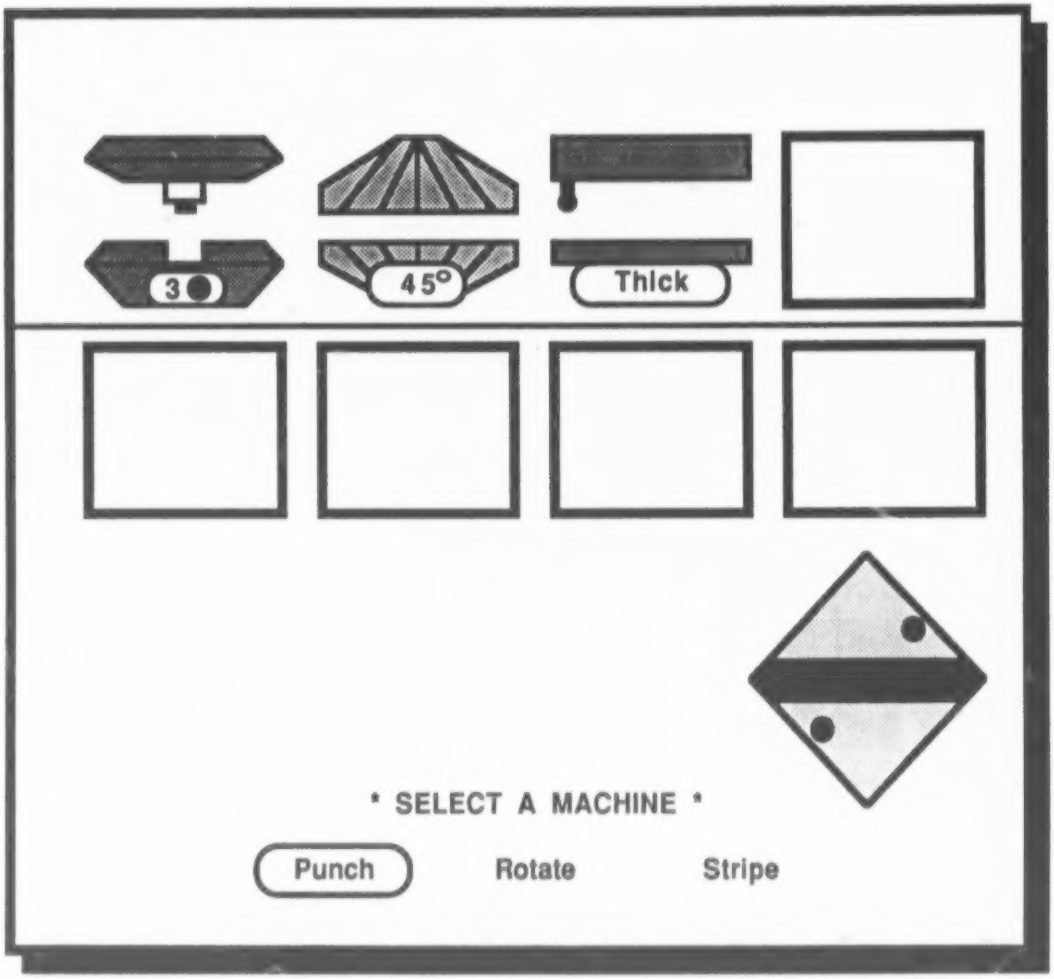
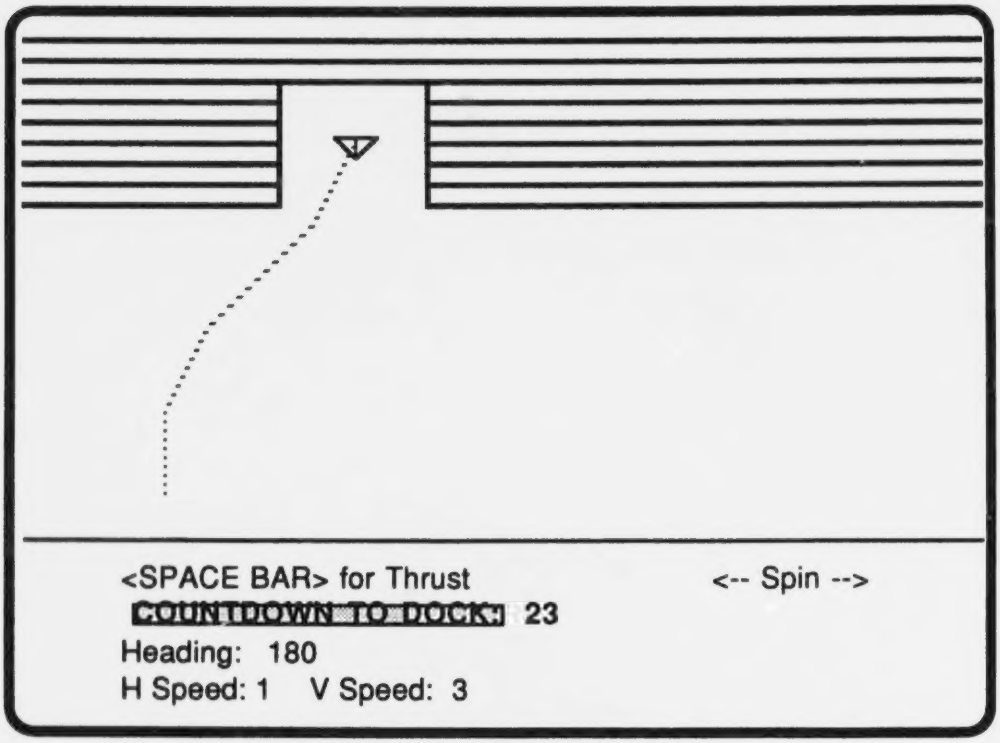

3●
45°
Thick
* SELECT A MACHINE *
Punch
Rotate
Stripe

Figure 2. An example of using animation as an aid to conceptual understanding: the student constructs a factory then watches the transformation of the "raw material".



<SPACE BAR> for Thrust

<-- Spin -->

COUNTDOWN TO DOCK: 23

Heading: 180

H Speed: 1 V Speed: 3

Figure 3. An example of using animation in an interactive dynamic: the student is in control of a free-floating "starship" attempting to dock with the "parent" ship.

Title:

The Effects of Computer Animated Lesson Presentations and Cognitive Practice Activities on Young Children's Learning in Physical Science

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The Effects of Computer Animated Lesson Presentations and Cognitive Practice Activities on Young Children's Learning in Physical Science

Abstract

The purpose of this study was to examine the effects of animated instruction and levels of practice on application learning in a computer-based instructional (CBI) science lesson. A total of 119 fourth and fifth grade students participated in an introductory lesson covering Newton's Laws of Motion. Three levels of Visual Elaboration (Static Graphic, Animated Graphic, No Graphic) were crossed with three levels of Practice (Behavioral, Cognitive, No Practice). Behavioral Practice consisted of traditional questioning after each of four lesson parts. Cognitive Practice consisted of a structured simulation where students were given increasing control over an animated "starship". Main effects was found for both Visual Elaboration and Practice. An interaction was also found between Visual Elaboration and Practice. Other data, such as response latency, attitudes, student perceptions, and incidental learning, was also collected.

Introduction

One of the goals of instructional design is to match the needs of instruction with the capabilities of the delivery system (Gagne', Briggs, & Wager, 1987). This implies that lesson design should be derived from learner and instructional variables, rather than machine variables. However, given the fact that new technologies provide new instructional design opportunities, instructional designers must consider which instructional attributes of a given delivery system actually delivery the most appropriate external lesson events in order to activate the internal learning processes which meet the lesson goals and objectives.

Many pitfalls plague the introduction of a new technology to education (Salomon & Gardner, 1986). A common tendency when designing instruction with a new technology is to mimmick the "status quo" in an older or traditional technology (Siegel & Davis, 1986; Streibel, 1986). In contrast, new technologies have historically been prone to the misconception that they are innately superior to traditional approaches. This latter pitfall has experienced a cycle of reoccurence during the past 30 years with such "new" technologies as programmed instruction, instructional television, computer-based instruction (CBI), computer programming (e.g. LOGO), and more recently interactive video (Salomon & Gardner, 1986). Clark (1983, 1985) has warned and cautioned against encouraging this misconception quite convincingly.

While it is generally agreed that CBI is just another instructional medium which acts as the delivery "truck" for instruction (p. 445, Clark, 1983), it is contended that the potentials of CBI have not as yet been fully realized (Hannafin & Rieber, 1986; Streibel, 1986). Salomon and Gardner (1986) have stated that "researchers have learned that only specific, relatively unique features of a medium make a difference" (p. 14). Many features of CBI appear to offer instructional opportunities which might be able to make a difference — features which are difficult or impossible to incorporate with most other media. Animation is one such feature.

There is a strong and rich historical perspective that humans are particularly adept visual learners. The research of Paivio (1979, 1983) and others (Intraub, 1979; Kobayashi, 1986; Kosslyn, Holyoak, & Huffman, 1976; Madigan, 1983) have expressed an apparent processing "partnership" between verbal and visual learning. According to this dual-coding theory, words and pictures activate independent visual and verbal codes. When the information to be learned is highly imageable, a learner is able to encode the information into long term memory (LTM) using both a verbal and visual trace. This redundant encoding increases the probability of retrieval since if one memory trace is lost (whether visual or verbal) the other is still available.

The dual-coding perspective presents a theoretical underpinning to support the use of visuals, whether static or animated, in instruction. Recent reviews support the use of instructional visuals

(Dwyer, 1978; Kobayashi, 1986; Levie & Lentz, 1982; Levin & Lesgold, 1978). However, it is uncertain whether animated visuals offer anything unique to instruction. Typically, CBI has used animation to create interesting (and potentially distracting) lesson reinforcers. A need exists to determine what features of animation have the potential to support instruction more directly. Interestingly, results from most animation studies have not supported the contention that animated visuals offer more instructionally than static visuals (Caraballo, 1985; King, 1975; Moore, Nawrocki, & Simutis, 1979; Rieber & Hannafin, 1988; Rieber, in press).

Perceptually, animation offers two attributes beyond that of static visuals: motion and trajectory (Klein, 1987). Therefore, animated visuals should be most effective when the attributes of motion and trajectory are congruent to the demands of the instructional task. Instruction in physics presents many examples of this. Research has shown that many students have deep-seated misconceptions about physical laws (diSessa, 1982) and traditional instruction often serves to conflict and contradict these "personal theories" (Champagne, Klopfer, & Gunstone, 1982). Designing instruction to include verbal descriptions as well as animated descriptions of "motion" concepts should improve learning. If the concepts to be learned include motion and trajectory, then the proper use of animation is believed to have the potential to increase learning through a visual elaboration process. Congruency between presentation and task variables is one groundrule cited in the review by Levin and Lesgold (1978) for the efficacy of pictures in reading. Differentiated effects between animated and static visuals is contended to be an extension of this groundrule.

Practice is another instructional variable which has been studied extensively during the past two decades (Hamaker, 1986) and which has recently been studied in CBI. CBI studies have shown that practice can be a very powerful influence on student achievement (Hannafin, Phillips, Rieber, & Garhart, 1987; Hannafin, Phillips, & Tripp, 1986). Traditional practice is operationally defined as asking enroute questions during instruction and is based largely on the pioneering work of Rothkopf (1966) and others. The use of practice in this sense follows a more behavioral approach which calls for frequent rehearsal of relevant lesson information with appropriate feedback and reinforcement (Wager & Wager, 1985). Behavioral practice activities are believed to most effective for lower-level or fact learning. However, CBI again affords many different approaches to practice which provide a more imaginative and innovative use of the medium (Salisbury, 1988; Salisbury, Richards, & Klein, 1985). A more cognitive approach to the design of practice activities would more actively involve the student in the instructional process. Practice of this sort would encourage mental conflicts to arise which could be resolved by the student through strategies such as informal hypothesis testing. Therefore, practice activities which encourage varied and deeper levels of cognitive processing would rely on situations of "critical confusion" (Norman, 1978) or disequilibrium (in the Piagetian sense). Cognitive practice activities, though less reliable and efficient for lower-level learning, would be of greatest value for higher-level learning.

The purpose of this study was to study the effects of animated instruction and practice on application learning in a CBI science lesson with concepts related to motion and trajectory. There were several hypotheses in this study: 1) animated instruction would be more effective in presenting the lesson content than instruction containing static visuals or no visuals; 2) Cognitive Practice activities, which encourage process over content, would better facilitate higher-level learning than Behavioral Practice activities; and 3) practice of any type would be of greatest value where the lesson elaboration support was minimal.

Methods

Subjects

The subjects consisted of 119 fourth and fifth graders from a rural public elementary school in central Texas. Participation was voluntary and selection based on parent consent. A total of 55 fourth and 64 fifth graders participated with an average age of 10.41 years (SD=.83).

CBI Lesson Content

The CBI lesson, first developed for previous studies (Rieber & Hannafin, 1988; Rieber, in press), described and explained Isaac Newton's Laws of Motion. The lesson was divided into four parts. The first lesson part introduced the learner to Isaac Newton's formal discovery of certain physical laws as well as several basic principles such as Newton's first law. The second part introduced the concept that equal but opposite forces are needed to cause objects to stop. This section dealt only with one-dimensional space. The third part expanded this notion to include the effects of unequal forces acting upon a stationary object. The third part also presented these concepts in one-dimensional space. Finally, the fourth part added the notion of two-dimensional space to the above concepts. All instruction was presented at an introductory level. Approximately 60 minutes was required to complete the lesson.

Lesson Versions

Three levels of Visual Elaboration (Static Graphic, Animated Graphic, No Graphic) were crossed with three levels of Practice (Behavioral, Cognitive, None). The respective practice activity was provided immediately after each of the four lesson parts.

Behavioral Practice. Behavioral Practice consisted of 5 multiple-choice questions presented after each of the four lesson parts. The questions covered the relevant material in that lesson part. Feedback was provided to the students in the form of knowledge of correct results. This practice type is termed behavioral due to the largely reinforcing nature of the practice activity.

Cognitive Practice. Cognitive Practice consisted of an activity which involved the student in a structured simulation involving the science concepts. Students were given increasing levels of control over a simulated, free-floating object. The free-floating object was called a "starship" and was represented by a triangular symbol on the computer screen. For example, students practiced increasing and decreasing the speed of the starship after lesson part 3 and practiced how forces acting on an object in 90 degree increments affect the final trajectory of the object in two dimensional space after lesson part 4. This practice activity is an application of the "dynaturtle microworld" developed by diSessa (1982) and others (White, 1984). An example of Cognitive Practice is depicted in Figure 1.

Insert Figure 1 About Here

No Practice. This level acted as a control. No practice activity was given to the student. Students in this condition progressed sequentially through the lesson parts.

Each of the three levels of Practice was crossed with three levels of Visual Elaboration (Static Graphic, Animated Graphic, No Graphic). Visual elaborations were added to those lesson parts judged as the most difficult and most needing additional instruction as determined from previous research (Rieber & Hannafin, in press; Rieber, in press).

Static Graphic. The textual presentation of the science instruction was supplemented by embedding static graphics throughout the lesson. These graphics provided static illustrations of the science content. Forces were represented graphically by a foot giving an object a kick, such as ball. Motion and trajectory attributes were represented by arrows and path lines. An example of a computer screen containing a static graphic elaboration is illustrated in Figure 2.

Insert Figure 2 About Here

Animated Graphic. The supplemental instruction was in the form of supportive, animated graphics. This condition also used the foot and ball symbols to represent an object being acted upon by forces. However, the ball was then animated to demonstrate the consequences of the forces on its movement. For example, a stationary ball was shown being kicked two times to the right. The ball was animated across the screen to the right and then stopped by two kicks to the left. This demonstrated the principle that an equal force in the opposite direction is needed to stop the object. An example of this is illustrated in Figure 3.

Insert Figure 3 About Here

No Graphic. This level also acted as a control. No visual support was added to the lesson in this condition. The textual material for this condition was identical to that provided in the other two conditions.

Dependent Measures

Lesson Posttest. The posttest consisted of 26 questions measuring application learning corresponding roughly to rule-learning as defined by Gagne (1985). Multiple-choice questions (1 answer and 4 distractors) were used as the testing format. The posttest measured student performance on the following six lesson objectives:

1) apply the rule that, without any outside forces, an object in motion will remain in motion and an object at rest will remain at rest (Newton's First Law);
2) apply the rule that, in one-dimensional space, when an object at rest is put into motion by a force, an equal force applied in the opposite direction is needed to stop the object;
3) apply the rule that, in one-dimensional space, when an object at rest is acted on by unequal forces, the final speed of the object is the result of the sum of the forces acting on the object from both sides;
4) apply the rule that, in one-dimensional space, when an object at rest is acted on by unequal forces, the final trajectory of the object is the result of the sum of the forces acting on the object from both sides;
5) apply the rule that, in two-dimensional space, forces occurring at right angles to each other act independently on the object (orthogonality); and
6) apply Newton's second law, summarized by the equation force=mass times acceleration (F=ma).

Objectives 1 to 5 are listed hierarchically such that each objective (starting with 1) is generally considered prerequisite to the next. Mastery of later objectives is believed to be dependent upon mastery of the earlier objectives. Objective 6 was not intentionally taught in the lesson material, but was implied only in the animated graphics condition. This objective was included to try to measure the incidental learning effect of animation. Thus, the six objectives are listed in order of difficulty (easiest to hardest). The format of the posttest questions was approximately half all-verbal and half verbal/visual. About half of the verbal/visual questions involved animation. No feedback was provided after each question. Students were not given their performance scores at the end of the posttest, instead all were informed that they had "passed". KR-20 reliability of the posttest was .87.

Response Latency. The time required by students to answer each posttest question was measured to the nearest second. Processing time was measured as the time required by students to answer each of the posttest questions once prompted to do so. The prompt was the final text displayed on the screen for each question.

Attitudes. Students' general attitudes about computers, science, and the lesson, were surveyed at the end of the lesson after they had been informed by the computer that they had "passed". Additionally, students were asked for their perception of lesson difficulty. All of these survey questions were presented using a five point Likert-type scale with "1" being the most positive, "5" the most negative, and "3" being neutral.

Procedures

All instruction and testing was administered by computer. As students arrived to the computer lab, they were randomly assigned to one of the treatment groups. Before beginning the lesson, all students were given a group orientation to the lesson. The orientation provided basic information about the location of computer keys and other protocols in order to minimize confusion and distraction during the lesson. Once instructed to begin, students completed the computer lesson individually. The posttest was automatically administered to each student upon completion of the four lesson parts. Immediately after completing the posttest all students were informed that they had passed the lesson, upon which the attitude survey was administered. Approximately one hour was needed to complete the lesson.

Design and Data Analysis

A 3 X 3 X (6) factorial design was used to study the effects of the instructional variables on students' application learning. Two between-subjects factors (Visual Elaboration, Practice) were crossed with one within-subjects factor (Learning Objective). The between-subjects factors consisted of three levels of Visual Elaboration (Static Graphic, Animated Graphic, No Graphic) and three levels of Practice (Behavioral, Cognitive, No Practice). The within-subjects factor consisted of the six learning objectives which also served as a dependent measure. Statistical procedures included mixed-effects analysis of variance (ANOVA) and Tukey's studentized range test for follow-up multiple-comparisons on means.

In addition, two separate analyses were conducted on the response latency and attitudinal variables.

Results and Discussion

Posttest

Percent means and standard deviations of student posttest scores are contained in Table 1. The ANOVA summary table is contained in Table 2. A significant main effect was found for Visual Elaboration, $F(2,660)=6.09$, $p=.002$. Students in the Animated Graphics group scored significantly higher on the posttest than those in the No Graphics or Static Graphics groups. No significant difference was detected between the Static Graphics and No Graphics groups.

Insert Table 1 About Here

Insert Table 2 About Here

A significant main effect was found for Practice, *F*(2,660)=5.83, *p*=.003. Students in the Cognitive Practice group scored higher on the posttest than those in the No Practice group. Although the Cognitive Practice group mean (57.3%) was larger than the Behavioral Practice group mean (50.9%), this effect size was not large enough to be significant. No significant difference was found between the Behavioral Practice and No Practice groups.

A significant main effect was found for Learning Objective, *F*(5,660)=21.86, *p*=.0001. As expected, learning was not uniform across all of the lesson objectives. Three distinct difficulty ranges emerged. Overall, students performed best on the group of test items measuring objectives 1, 2, 3, and 4 (mean=59.6%). Next in difficulty were the questions measuring objective 5 (mean=44.8%). Finally, students found test items for objective 6 the most difficult (mean=28.6%). These results partially support the earlier contention that the objectives were hierarchically organized. Not surprisingly, students had more difficulty on objective 7 (just above the level expected from guessing) since this objective was not taught directly in any of the treatments, and only incidentally in the Animated Graphic treatment. Follow-up analyses indicated a marginal effect for Visual Elaboration on this objective. Students in the Animated Graphic treatment outperformed the Static Visual and No Visual groups at *p*=.09.

A significant interaction was detected between Visual Elaboration and Practice, *F*(4,660)=4.28, *p*=.002. The nature of this interaction is shown in Figure 4. Students who received Behavioral Practice performed best on the posttest when also given instruction presented with Animated Graphics than with Static Graphics or No Graphics. Students receiving Cognitive Practice did not vary significantly on the posttest based on which type of visual elaboration was used.

Insert Figure 4 About Here

Response Latency

A main effect was found for Practice, *F*(2,660)=10.92, *p*=.0001. Students who received practice (Behavioral or Cognitive), took significantly less time to answer the posttest questions than students who did not receive practice.

A main effect was found for Learning Objective, *F*(5,660)=35.19, *p*=.0001. In general, students took longer to respond to difficult questions than easy questions. There was one exception to this pattern: students needed as much time to answer questions covering objective 1 (the easiest objective) as they did for objectives 5 and 6 (the most difficult questions). This exception was not predicted and is not readily interpretable.

Attitudes

No effects on attitude were found for either Visual Elaboration (mean=1.46) or Practice (mean=1.46). Overall, students displayed favorable attitudes (between positive and very positive) regardless of which treatment they were given.

General Discussion

The purpose of this study was to study the effects of different levels of visual elaborations and different levels of practice on application learning in a CBI science lesson. This study was an extension of previous research investigating instruction using computer animation coupled with practice activities. The science material covering Newton's laws of motion was chosen for its conceptual density, the lack of student experience with the material, and its obvious congruency with animated instruction. Previous research using this material demonstrated that students found the material very difficult, a factor which was believed to explain, at least partially, why no differences were found previously. Although the lesson material was extensively modified in the present study, students still found the content very difficult, as shown by the mean scores in Table 1. In this study, however, the nature of the visual elaboration and practice activity had an influence on student's application learning of the material.

Instruction containing animated elaborations of the lesson content had a definite influence on student performance as compared to static graphics or no graphics. All of the lesson objectives involved concepts and principles which were not only highly visual in nature, but also directly involved the attributes of motion and trajectory. It was hypothesized that students who were given precise representations, illustrations and examples of these concepts and principles would be in a better position to understand, retain, and retrieve the information and ideas than students who were not given adequate elaborations. This hypothesis was supported by the main effect on the Visual Elaboration factor.

Practice as an instructional activity has a long history of support. Previous research with this science material with this student population has indicated that practice has little effect when the lesson material is exceedingly difficult. In fact, under those conditions practice can be counterproductive. When practice requiring significant mental investment was required by the students already given the heavy cognitive strain of the lesson content, as in the Rieber and Hannafin (1988) study, students seemed to experience a kind of cognitive overload which lowered posttest performance. This is similar to the Yerkes-Dodson law where performance decreases as the amount of arousal surpasses an optimal level. Salomon (1983) has maintained that student perceptions of the amount of mental effort required by the instruction is a critical factor in learning. Students who incorrectly perceive material as easy fail to process the material effectively or thoroughly. Conversely, students who perceive material as too difficult are unwilling, or see themselves as unable, to learn. Interestingly, when students in this study were asked their perceptions of the ease or difficultly of the lesson they responded overall neutrally (mean=2.4 on the five point scale where one was "very easy" and five was "very difficult") irrespective of the treatment condition. This perception is clearly in contrast with the students' apparent experienced difficulty as evidenced by the posttest scores. Although the fact that all students were told that they had "passed" may have influenced their perceptions, they clearly failed to perceive lesson difficulty accurately. One resulting premise from this might be that the responsibility of instruction to keep students on-task in meaningful ways is increased when student perceptions about the amount of required mental effort are inaccurate.

In the Rieber (in press) study, students did not benefit significantly from traditional post-questioning as a practice technique. In the present study, this type of traditional practice, called Behavioral Practice, again did not produce an effect. However, activities in the Cognitive Practice group, which allowed students to participate in a structured simulation requiring them to manipulate the science concepts and principles, appeared to be effective. The Cognitive Practice activities were thought to promote deeper levels of mental processing (as defined by Craik & Lockhart, 1972). Students were forced to actively engage in the processes of the science material rather than merely studying the content. This is consistent with previous research which indicates that behaviorally-based activities are more effective for lower-level learning, whereas cognitively-based activities are more effective for higher-level learning (Clark, 1984). Partial differentiation between the effects of behaviorally-based versus cognitively-based practice activities on higher-level learning is supported by the results reported here. Both practice activities seemed to aid students in organizing the material as evidenced in the decreased response time in the Practice versus No Practice groups. Students in Practice groups were more familiar with using and applying the rules and were in a better position to readily select the appropriate rule for answering each posttest question than students in the No Practice group. This latter group was overtly required to apply the rules for the first time during the posttest.

Lastly, one contributing factor which helps explain why an effect was produced for Cognitive Practice and not Behavioral Practice (as compared to No Practice) was that Cognitive Practice was probably very intrinsically motivating for students of this age level, an important characteristic for maintaining interest and keeping students on-task longer (Malone, 1981). The students were encouraged to fantasize about being the pilot of a starship in outer space.

The interaction between Visual Elaboration and Practice was interesting. An interaction between these two factors was predicted. It was hypothesized that students would benefit from practice activities most when the lesson presentation support was minimal. Instead, students benefited most from the animated instruction when the practice support was moderate. In other words, the animated instruction provided more support for the relatively weak behavioral practice activity than for the cognitive practice activity. However, the benefits of the animated instruction were eliminated without practice. Students did not benefit from the behavioral practice unless it was used in tandem with the animated elaborations. Animated instruction coupled with traditional questioning facilitated results similar to those produced by the Cognitive Activities. It may have been that the occasional questioning encouraged students to attend more closely to the animated visual cues provided during the lesson. The animated elaborations presented without any practice support were no more beneficial than either static graphics or no graphics.

One interesting finding concerns the degree of incidental learning resulting from animated instruction. As previously indicated, lesson objective six tested the application of Newton's second law concerning the relationship between force, mass, and acceleration. This laws explains that when two objects of different masses are both acted on by the same size force, the initial acceleration experienced by the object with larger mass is less. This principle was never directly taught, but was implied solely in the animated instruction. One animated elaboration illustrated a large solid box moving very slowly across the computer screen after being kicked with the same force which had just previously animated a small ball moving quickly across the screen. No attempt was made to intentionally teach or explain why the box moved more slowly than the ball. Students receiving Animated Graphics scored higher on this objective at $p=.09$. Students seemed to be attending to the appropriate details of the animation which pertained to this principle although they were not prompted to do so.

The strong positive attitudes and lack of differentiation between the lesson conditions are not surprising. Any potential differences were probably overridden by novelty and Hawthorne effects. Students enjoyed the opportunity and the attention received which resulted from their participation and this seemed to carry over to their general attitudes about computers, science, and the lesson.

In summary, the results of this study indicate that animation can serve as an effective instructional aid. However, given the track record of animation research, the efficacy of animation is obviously very subtle and difficult to draw out — animation has yet to be proven as a potent instructional variable. Previous research has indicated that students do not always attend to the additional visual prompts provided by animation (Rieber, in press). Given proper conditions, animation can serve to influence student achievement. These conditions include using animation to teach lesson material which involves motion and trajectory, lesson material which is adequately challenging but not unreasonably so, and also using animation in tandem with other supportive instructional activities such as practice. Future research is needed to clarify the specific nature of the interaction of animated instruction and practice. More information and insight is needed to demonstrate other content areas where animated instruction could be expected to be congruent to the demands of the material.

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Table 1

Mean Percent Scores and Standard Deviations for the Posttest

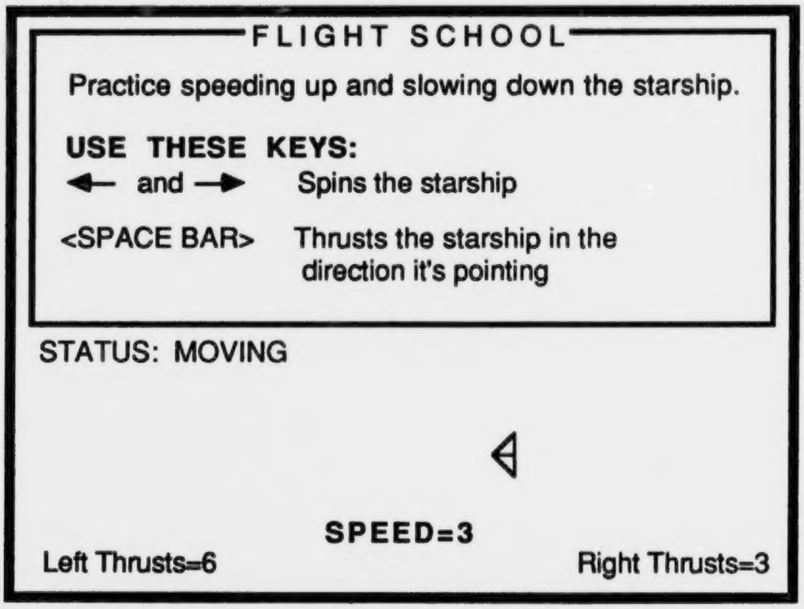
		Practice		
Visual Elaboration		Behavioral	Cognitive	No Practice
Static Graphic	Mean	44.6	51.3	51.3
	SD	(30.5)	(33.2)	(33.1)
	n	15	12	13
Animated Graphic	Mean	66.0	61.6	47.2
	SD	(31.6)	(34.7)	(33.2)
	n	11	14	14
No Graphic	Mean	44.9	58.1	45.3
	SD	(32.6)	(34.1)	(30.4)
	n	12	14	14

Table 2

ANOVA Summary Table

Source	*DF*	*MS*	*F*	Probability
(V)isual Elaboration	2	5662.42	6.09	0.002*
(P)ractice	2	5423.62	5.83	0.003*
(V)(P)	4	3985.85	4.28	0.002*
Error	660	930.49		
(L)esson Objective	5	20338.72	21.86	0.0001*
(V)(L)	10	799.53	0.86	0.571
(P)(L)	10	1268.25	1.36	0.193
(V)(P)(L)	20	667.39	0.72	0.811
Error	660	930.49		

*p<.01



FLIGHT SCHOOL

Practice speeding up and slowing down the starship.

USE THESE KEYS:

← and → Spins the starship

<SPACE BAR> Thrusts the starship in the direction it's pointing

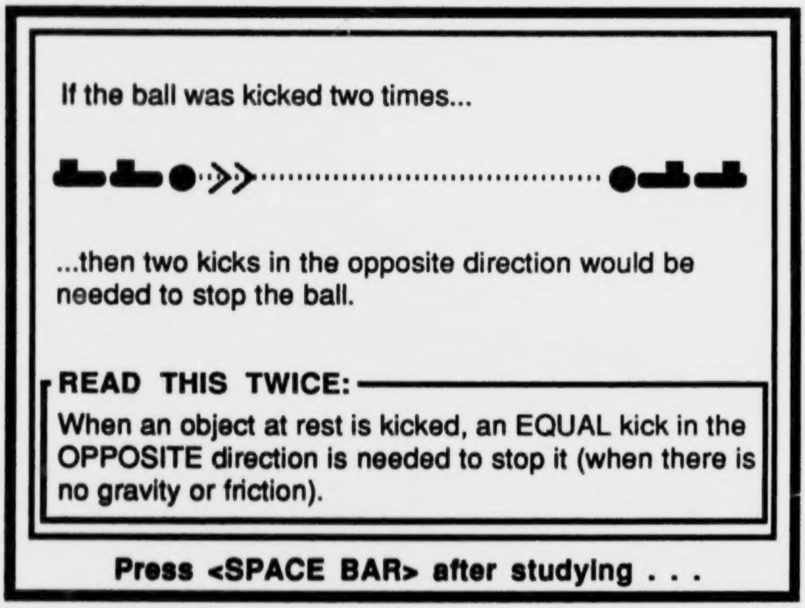
STATUS: MOVING

SPEED=3

Left Thrusts=6

Right Thrusts=3

Figure 1. Snapshot of the computer screen during an episode of Cognitive Practice. (Animated starship is under student control. Arrow keys spin the starship in 180 degree increments resulting in one-dimensional motion.)



If the ball was kicked two times...

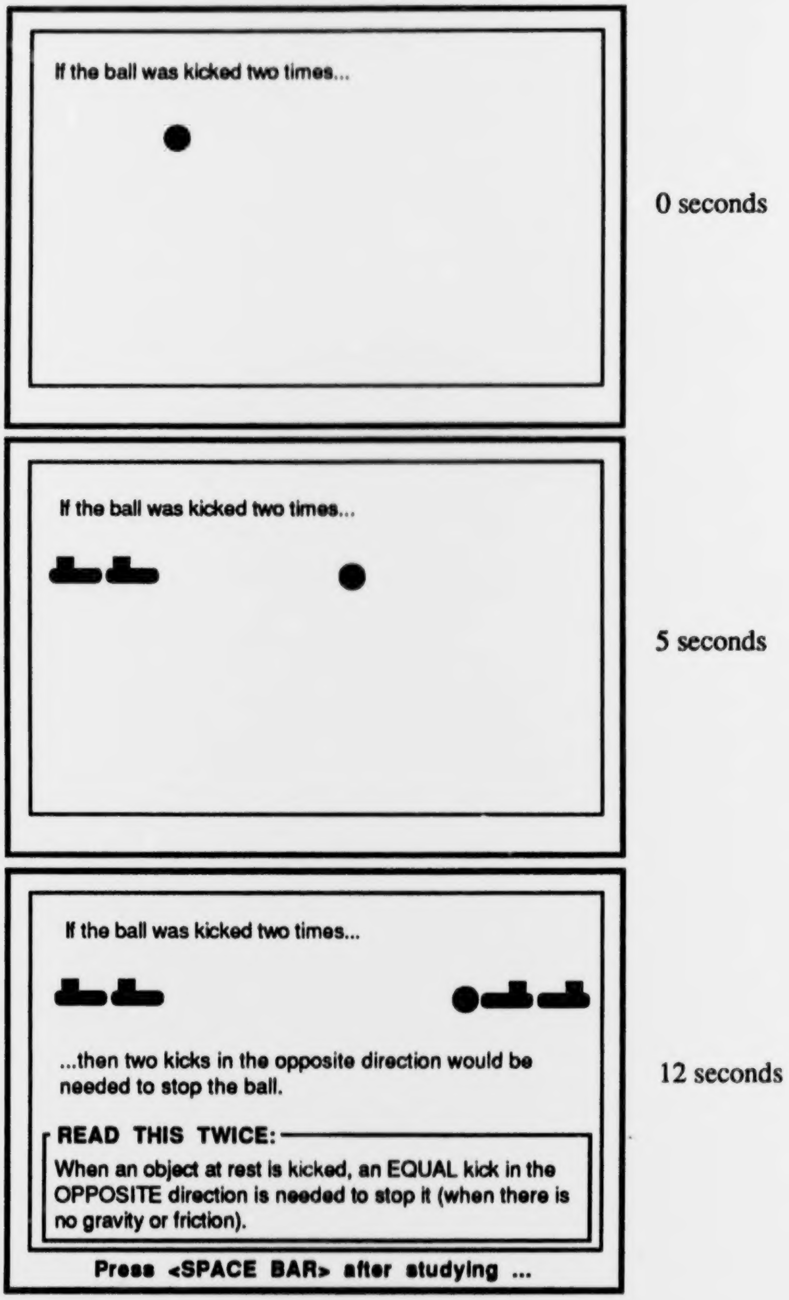
...then two kicks in the opposite direction would be needed to stop the ball.

READ THIS TWICE:

When an object at rest is kicked, an EQUAL kick in the OPPOSITE direction is needed to stop it (when there is no gravity or friction).

Press <SPACE BAR> after studying . . .

Figure 2. Example of a computer screen which includes a static visual elaboration.



If the ball was kicked two times...

If the ball was kicked two times...

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...then two kicks in the opposite direction would be needed to stop the ball.

READ THIS TWICE:

When an object at rest is kicked, an EQUAL kick in the OPPOSITE direction is needed to stop it (when there is no gravity or friction).

Press <SPACE BAR> after studying ...

Figure 3. Time-lapse sequence of an example computer screen which includes an animated visual elaboration.

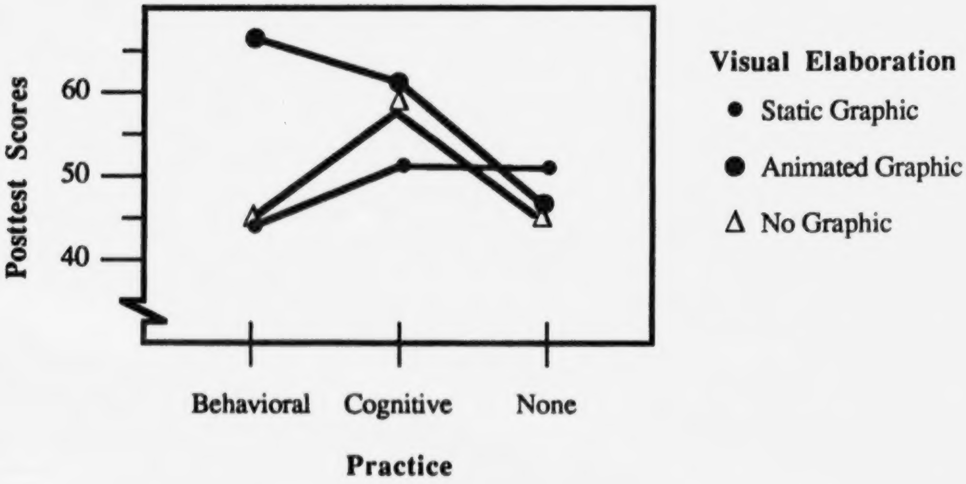

Figure 4. Interaction between Visual Elaboration and Practice.

Title:

The Effects of Computer Animated Lesson Presentations and Cognitive Practice on Adult Learning in Physical Science

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The Effects of Computer Animated Lesson Presentations and Cognitive Practice on Adult Learning in Physical Science

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The Effects of Computer Animated Lesson Presentations and Cognitive Practice on Adult Learning in Physical Science

Abstract

The purpose of this study was to examine the effects of different levels of visual elaborations and practice on application learning of adults in a computer-based science lesson. A total of 141 university students participated in an introductory lesson covering Newtonian mechanics. Three levels of Visual Elaboration (Static Graphic, Animated Graphic, No Graphic) were crossed with three levels of Practice (Behavioral, Cognitive, No Graphic). Behavioral Practice consisted of traditional questioning after each of four lesson parts. Cognitive Practice consisted of a structured simulation involving the control of an animated "starship". No effects were found for Visual Elaboration. The addition of static and animated visuals to the text had no effect on learning. An effect was found for Practice such that both types of practice were effective (as compared to a control), but no differences between them were detected. Main effects were found for Visual Elaboration and Practice based on response latency data from the posttest. A moderately significant interaction between Visual Elaboration and Practice indicated several trends for future research.

Introduction

Since the introduction of microcomputers in educational settings, a great variety of instructional applications have been presented. Most recent designs of computer-based instruction (CBI) have attempted to create instructional environments which integrate wide ranges of learning outcomes encompassing recent advances in learning theory and instructional design (see for example Jonassen, 1988; Wager & Gagné, 1988; Ross & Morrison, 1988; Tennyson & Christensen, 1988). Despite these advances, we know surprisingly little about some of the computer's most basic presentation attributes. Animation is one such attribute which has little empirical support although it is widely incorporated as a CBI presentation strategy (Rieber, 1989a).

General theoretical support for visual presentations, of which animation is a subset, comes from several information-processing learning theories (Gagné, 1985). Imagery, the visualization of knowledge in continuous dimensions, has been shown to be particularly useful in working memory because of the compact manipulation of spatial information (E. Gagné, 1985). Whether imagery is used as extensively in long term memory is not as conclusive. One theory supporting visualization's role in long term memory is the dual-coding hypothesis (Paivio, 1979, 1983) which suggests that highly imageable, concrete information is stored both verbally and visually. Retention can be enhanced by external pictures if they promote the activation of dual-coding. When information is dual-coded, the probability of retrieval is increased since if one memory trace is lost, another is still available (Kobayashi, 1986).

Of the few empirical studies that have been reported investigating the effects of animation as a presentation variable with adults few have indicated positive results (see, for example, Caraballo, 1985; King, 1975; Moore, Nawrocki, & Simutis, 1979; Reed, 1985; and Rigney & Lutz, 1975). However, factors such as the limited number of studies, evidence of procedural flaws, and other confounding in some of these studies, make generalization difficult. Recently, Rieber (1989b) reported positive results when animated visuals were used to present science concepts and rules to young children, but only under certain conditions (eg. animation congruent to learning task, careful cueing to attend to animation, and the use of optimally difficult material). Related research in mental imagery has indicated maturation effects. Older students consistently rely less on external images than younger students (Pressley, 1977). Whether the previous lack of animation effects with adults was due to maturation effects or to inappropriate or insufficient research is open to question and was the basis for this study.

Besides visualization, animation also offers the attributes of motion and trajectory to instructional presentations (Klein, 1987). Animated visuals should be expected to promote learning when motion and trajectory attributes are congruent to the learning task and students are unable to mentally construct such attributes on their own adequately. Many objectives in physics instruction present examples of this. Problems in teaching physics concepts have also been compounded by many reports of student misconceptions of the physical world (diSessa, 1982).

Practice has long been accepted as an effective learning strategy. Many practice strategies are operationally defined as asking questions before, during, and/or after instruction (Hamaker, 1986). This type of practice tends to be somewhat behavioral in nature — enhancing factual and conceptual learning through repetition. While this type of practice is effective (see for example Hannafin, Phillips, Rieber & Garhart, 1987; and Hannafin, Phillips, & Tripp, 1986), especially for lower-level learning outcomes, it tends to become monotonous or boring for the student and relies heavily on extrinsic motivation. In CBI, this type of practice has been commonly applied to much tutorial and drill and practice software.

Practice does not have to be limited to just the encoding of facts, but can also aid higher-level cognitive processing (Salisbury, 1988; Salisbury, Richards, & Klein, 1985). This type of practice involves presenting the learner with problems or conflicts that need resolved through higher-level processing such as informal hypothesis-testing. This is a more cognitive approach to practice design in that it provides intrinsic motivation (Malone, 1981) for students to become involved in deeper levels of mental processing. CBI affords many innovative and relatively unique practice scenarios to be designed.

The purpose of this study was to study the effects of animated instruction and practice on adult learning in science. This study was a replication of the study by Rieber (1989b) which found effects of animated visuals on children's learning. In this experiment the question of whether animated visuals would also influence adult learning or if adults would be able to sufficiently construct such images internally thus making the addition of animated visuals unnecessary was studied. Additionally, the role of varied practive activities and their relationship to presentation variables were also studied.

Methods

Subjects

The subjects consisted of 141 upperclass undergraduate students (juniors and seniors). All of the students were education majors currently enrolled in an introductory computer education course. Participation was voluntary, though extra credit in the enrolled course was provided as an incentive to participate. A total of 122 females and 19 males participated.

CBI Lesson Content

The CBI lesson described and explained Isaac Newton's Laws of Motion. The lesson was divided into four parts. The first part introduced the student to fundamental background vocabulary and concepts, such as mass, weight, inertia, force, velocity, and acceleration. This part also formally presented Newton's first law of motion. The second part introduced Newton's second law of motion and then described applications of Newton's first and second laws given equal forces in opposite directions in one-dimensional space. The third part extended the application of Newton's first and second laws to include the effects of unequal forces in one-dimensional space. The fourth part introduced and explained Newton's third law and applications in two-dimensional space. All instruction was presented at an introductory level intended for novices. The lesson was designed to exclude as much formal mathematics as possible and instead concentrated on concept formation and application. Approximately 60 minutes was required to complete the lesson.

Lesson Versions

Three levels of Visual Elaboration (Static Graphic, Animated Graphic, No Graphic) were crossed with three levels of Practice (Behavioral, Cognitive, None). The respective practice activity was provided immediately after each of the four lesson parts.

Behavioral Practice. This consisted of five multiple-choice questions presented after each of the four lesson parts for a total of 20 practice questions. The questions covered the application of information contained in each respective lesson part. Informative feedback was provided to the students in the form of knowledge of correct results. This condition is described as behavioral due to the reinforcing nature of the practice activity.

Cognitive Practice. This activity consisted of a structured simulation. Students were given increasing levels of control over a simulated, free-floating object. This object was called a "starship" and was represented by a triangular symbol on the computer screen. This practice activity is an application of the "dynaturtle microworld" developed by diSessa (1982) and others (White, 1984). This practice activity is an example of a "learning-by-doing" application of animation (Brown, 1983), also described as an interactive dynamic (Rieber, 1989a). For example, students practiced increasing and decreasing the starship's speed after lesson part 3 and practiced controlling the starship when forces are applied to it orthogonally (in 90 degree increments) in part 4.

No Practice. This level acted as a control. No practice activity was given to these students, instead, they progressed sequentially through the four lesson parts.

Each of the three levels of Practice was crossed with three levels of Visual Elaboration (Static Graphic, Animated Graphic, No Graphic). Visual elaborations were added to an all-text lesson script. These visual elaborations were added at regular intervals at locations in the text where particular rules and applications of one or more rules were being explained.

Static Graphic. The textual presentation of the science instruction was supplemented by static graphics. These graphics provided static illustrations of the science content. Forces were represented graphically by a foot giving an object (usually a ball) a kick. Motion and trajectory attributes were represented by arrows and dotted path lines.

Animated Graphic. In this condition, each static graphic was replaced with an animated graphic. The foot and ball graphics were also used to show an object being acted upon by forces, however, the ball was additionally animated to demonstrate the consequences (in terms of speed and trajectory) on its movement. For example, a stationary ball was shown being kicked two times to the right. The ball was animated across the screen to the right and then stopped by two kicks to the left. This demonstrated the principle that an equal force in the opposite direction is needed to stop the object.

No Graphic. This level acted as a control. No visual support was added to the textual presentation in this condition. The textual material was verbatim to the other two Visual Elaboration conditions.

Dependent Measures

Lesson Posttest. The posttest originally consisted of 32 questions measuring application learning corresponding roughly to rule-learning as defined by Gagné (1985). However, 13 questions were subsequently removed before the final analysis due to their lack of discriminiation ability as indicated by follow-up item analyses. The remaining 19 questions were used in the final analysis. Multiple-choice questions (1 answer and 4 distractors) were used as the testing format. The posttest measured student performance on the following six lesson objectives:

1) apply the rule that, without any outside forces, an object in motion will remain in motion and an object at rest will remain at rest (Newton's first law);
2) apply the rule that, in one-dimensional space, when an object at rest is put into motion by a force, an equal force applied in the opposite direction is needed to stop the object;
3) apply the rule that, in one-dimensional space, when an object is acted on by unequal forces, the final speed and trajectory of the object is the result of the sum of the forces acting on the object from both sides;
4) apply the rule that, in two-dimensional space, forces occurring at right angles to each other act independently on the object (orthogonality);
5) apply Newton's second law, summarized by the equation force=mass times acceleration (F=ma); and
6) apply the principle of the relationship between acceleration and velocity.

The format of these questions was approximately half all-verbal and half verbal/visual and about half of the verbal/visual questions involved animation. No feedback was provided after each question, but students were given their total number of correct and wrong responses at the conclusion of the posttest. KR-20 reliability of the original 32 questions was .71.

Response Latency. The time required by students to answer each posttest question was measured to the nearest second. Response latency was measured as the time required by students to answer each of the posttest questions once prompted to do so. The prompt was the final text displayed on the screen for each question.

Notetaking. Students were provided paper for any notes they wished to take during the lesson presentation. These notes were analyzed in terms of content, style, quality, and quantity in relation to the lesson presentation in which they participated.

Post-lesson Survey. Upon completion of the lesson, students completed a post-lesson survey. Students were asked to respond to open-ended questions which addressed issues such as the difficulty of the lesson, how the lesson might have hindered their learning of the material, and how the lesson might have helped their learning of the material. The students comments were summarized with respect to the content and specific examples cited.

Procedures

All instruction and testing was administered by computer. Subjects were randomly assigned to one of the treatment groups as they reported to the lab. Before beginning the lesson, all students were given a group orientation to the lesson. All subjects were supplied with paper and asked that it be used for any notetaking. All notes were collected by the proctor at the end of the experiment. Once instructed to begin, students completed the computer lesson individually. The posttest was automatically administered to each student upon completion of the four lesson parts. Immediately upon completion, students were informed of their posttest score. Students were then asked to answer the post-lesson survey. Approximately one hour was needed to complete the lesson.

Design and Data Analysis

A 3 X 3 X (6) factorial design was used in this study. Two between-subjects factors (Visual Elaboration, Practice) were crossed with one within-subjects factor (Learning Objective). The between-subjects factors consisted of three levels of Visual Elaboration (Static Graphic, Animated Graphic, No Graphic) and three levels of Practice (Behavioral, Cognitive, No Practice). The within-subjects factor consisted of the six learning objectives which also served as a dependent measure. Statistical procedures included mixed-effects analysis of variance (ANOVA) and Tukey's studentized range test for follow-up multiple-comparisons on means. In addition, a separate analysis was conducted on the response latency data from the posttest.

Besides the quantitative measures, qualitative data in the form of student notetaking and post-lesson surveys were also also analyzed.

Results

Posttest

Percent means and standard deviations of student posttest scores are contained in Table 1. The ANOVA summary table is contained in Table 2. No main effects were found for Visual Elaboration, $F(2,660)=1.62, p=.199$. Students performed similarly on the posttest regardless of presentation strategy.

A significant main effect was found for Practice, $F(2,660)=12.19, p=.0001$. Follow-up analyses showed that students in the Cognitive Practice group (mean=76.4%) and Behavioral Practice group (mean=81.1%) both outperformed students in the no practice control group (mean=69.2%). No significant difference was indicated between the Cognitive and Behavioral Practice groups.

Insert Table 1 About Here

Insert Table 2 About Here

A significant main effect was found for Learning Objective, *F*(5,660)=3.37, *p*=.005. As expected, learning was not uniform across all of the lesson objectives. The follow-up analysis indicated a significant difference between posttest scores on objectives 2 (mean=80.1%) and 3 (mean=81.4%) and objective 6 (mean=70.1%). It was expected that students would find the final objective involving acceleration and velocity problems the most difficult.

A moderately significant difference was detected between Visual Elaboration and Practice, *F*(4,660)=2.19, *p*=.068. The nature of this interaction is shown in Figure 1. This interaction suggested two trends in the data. First, the Static Visual and No Visual groups appeared to be influenced more by practice than the animated visual group. That is, when practice was not provided, the Animated Visual group outperformed the other two visual groups. Second, it appeared that cognitive practice caused interference when the lesson was presented using animated visuals.

Insert Figure 1 About Here

Response Latency

A main effect was found for Visual Elaboration, *F*(2,660)=4.89, *p*=.008. Students in the Animated Graphic condition (mean=18 seconds) took significantly less time to answer posttest questions than either students in the Static Graphic (mean=20 seconds) or No Graphic (mean=20 seconds) conditions.

A main effect was found for Practice, *F*(2,660)=22.57, *p*=.0001. All three practice conditions were significantly different from one another. Students in the Cognitive Practice condition (mean=17 seconds) took significantly less time to answer the posttest questions than those in the Behavioral Practice condition (mean=19 seconds). Students in these two conditions took significantly less time to answer posttest questions than students in the No Practice (mean=22 seconds) condition.

A main effect was also found for Lesson Objective, *F*(2,660)=50.51, *p*=.0001. Three distinct ranges of response latency among the lesson objectives grouped the objectives as follows: the first group comprised objective 5 (mean=26 seconds); the second group comprised objectives 1 (mean=22 seconds), 4 (mean=21 seconds), and 6 (mean=20 seconds); and the third group comprised objectives 2 (mean=15 seconds) and 3 (mean=12 seconds). All three groups were significantly different from each other.

Note Taking

During the lesson students were permitted, although not prompted, to take any notes they wished. Of the 141 students, 82 students (evenly distributed across all presentation formats) filled most of an entire page with notes, and 26 students took no notes as all. The types of notes were consistently the same: lists of factual information, formulas, and statements of the laws of motion. Virtually no students added their own comments or interpretations of the information. Twenty-six students included diagrams reflecting solutions to some of the questions on the posttest.

Post-Lesson Survey

In response to consider which attributes of the lesson aided their learning, all groups mentioned that review, repetition, self pacing, and examples provided the greatest amount of help. In general, students recognized general lesson design features as aids to learning. Students in the Static Graphic condition specifically mentioned that the graphic displays were helpful, while students in the Animated Graphic condition mentioned that the animation and motion were helpful. Students in the No Graphic condition cited the lesson examples as being helpful.

With respect to practice, students in the Behavioral Practice condition specified the practice questions and examples as being helpful, while students in the Cognitive Practice condition referred to the participation, involvement, and "fun practice" as being helpful. Students in the No Practice did not make any additional comments.

When asked what might have hindered their learning, all groups mentioned the amount of information presented, expressing concerns that it was "too much". A second concern was not being able to return to a previous screen to review the material. It is interesting to note that students in the Animated Graphic condition mentioned that the "rolling balls" took too long, while students in the Static Graphic condition specifically mentioned that examples of a moving ball and kicks were needed. Students in the No Graphic condition specifically mentioned that pictures and graphics were needed and would have been helpful.

The Behavioral Practice group did not mention any specific concerns, but students in the Cognitive Practice were concerned that the program was lengthy, specifically in the practice activities. Many students in the No Practice condition expressed the concern that they were not completely prepared for the posttest.

General Discussion

The purpose of this study was to investigate whether previously indicated effects of animation used as part of presentation and practice strategies on children's learning of certain science material (Rieber, 1989b) would be replicated using adults. The science material taught Newton's three laws of motion and was chosen for its conceptual density and its obvious congruency with animated instruction. Previous research using this science material with young children has indicated animation and practice effects, but only under certain conditions. For example, in the Rieber (1989b) study young children benefited from animated presentation strategies only when the learning task was optimally difficult and when they were carefully prompted to attend to the animation. Other animation research with adult subjects has largely reported no significant differences. However, general imagery research points to maturation effects (Pressley, 1977) where an individual's dependence on external imaging prompts appears to fade with age. This study was an attempt to validate empirically the relationship of the visual effect of animation and maturation using material found to produce an effect with young children but revised (in terms of reading level and concept density) to reflect the adult sample.

No main effects for Visual Elaboration were found in this study. Adult subjects in this study were not influenced by the type of presentation strategy used. The verbal material was presented to subjects using highly imageable explanations and examples. Although subjects found the lesson material relatively difficult (overall mean = 75.6%) such that ceiling effects can be excluded, the addition of static or animated visuals to provide more concrete elaborations of the verbal material did not contribute to learning. This lack of effects for animated presentation strategies is consistent with previous research with adult learners.

It is contended that successfully performing the task requirements of this lesson required subjects to perform three imaging functions: 1) adequate visualization of the physical science material; 2) adequate and accurate imaging of differences in the motion of objects (i.e. moving, not moving, changes in speed); and 3) adequate and accurate imaging of the trajectory of objects (i.e. direction of the path of the moving object). The verbal presentation of the lesson material was designed to act as a stand-alone presentation vehicle. It sufficiently provided all information by way of highly imageable explanations and examples as well as prompts to students to image. It was believed that this design would support individuals capable of internally imaging these three functions. Students given an all-verbal presentation would be required to form internal mental images. Static and animated visual elaborations of the verbal information were then added to successively provide more concrete, external imaging devices. In this study, subjects provided with these external imaging devices performed as well as subjects who were given an all-verbal presentation.

The response latency data indicates that although animation did not affect learning, it helped to decrease the time necesssary to retrieve information from long-term memory and then subsequently reconstruct it in short-term memory. This retrieval process required students to reconstruct mental images. The animated visual presentation significantly aided the students in this mental visualization effort as compared to students in the static or no visual conditions. Comments on the survey from students in the visual groups that visuals helped them as well as comments from students in the No Visual group that visuals would have helped supports this contention.

Practice has a long history of support as an instructional activity. Not only is its use intuitively obvious, but is well supported in instructional design theory (Gagné, 1985). Operational definitions of instructional practice often turn out to be forms of questioning, largely a result of the pioneering work of Rothkopf (1966). However, advances in cognitive psychology coupled with instructional opportunities available with computer technology present many interesting practice activities not yet sufficiently tested or validated. In this study, two practice conditions were tested. The Behavioral Practice group received a traditional questioning activity, whereas the Cognitive Practice group participated in a structured simulation involving the control of an animated "starship" in a frictionless/gravity-free environment. Both practice groups significantly outperformed the No Practice control group. However, no significant differences were found between the practice groups. One conclusion of no great surprise is that interactivity of any sort aids learning more than no interactivity. However, it was expected that the cognitive activity would promote higher-level learning more than the behaviorally-based questioning approach. Several researchers have discussed the benefit of behavioral designs in promoting lower-level learning and cognitive designs for higher-level learning (Clark, 1984). In this study, both practice types were equally effective. This could have been caused by the fact that the questions sufficiently required students to process the information at deeper levels of processing or because students were not given enough time and experience with the cognitive activities to produce a differentiated effect. At the very least, the structured simulation activity has been partially validated as an innovative instructional activity shown to be as effective as more conventional practice activities.

The response latency data supports the contention that both practice conditions facilitated students' organization of the material and their understanding of the relationship among the many concepts and rules. Even though no differences in learning was indicated between the two practice groups, the Cognitive Practice group took even significantly less time to answer posttest questions than the Behavioral Practice group. This provides partial evidence of the fact that this group may have processed the information at a deeper level (as defined by Craik & Lockhart, 1972) than students in the Behavioral Practice group. Comments from students in the No Practice group accurately reflected their lack of preparedness for the posttest.

The moderately significant interaction between Visual Elaboration and Practice was interesting. Two trends were indicated. The first trend seemed to indicate that the Static Visual and No Visual groups were influenced more by practice (Behavioral and Cognitive) than the Animated Visual group. In other words, students appeared to benefit most from the practice activities when the lesson presentation support was minimal. The second trend seemed to indicate that some interference occurred between the animated lesson presentations and the cognitive practice activities. Reasons for this interference can only be speculated. Research indicates that children and adults have many misconceptions of physical science principles (Champagne, Klopfer, & Gunstone, 1982; diSessa, 1982). These misconceptions are based in part on each individual's personal theories of the physical world developed through daily experiences where the forces of gravity and friction are so prevalent. It is possible that the Cognitive Practice condition paired with precise animated presentations of the physical principles forced many students to confront several of these misconceptions. Since this experiment lasted only for one lesson, there was insufficient time and experience with the material to help students to remove or reconcile the inconsistencies between scientific reality and their misconceived "reality", hence, the students' learning of the material was interfered.

In summary, the results of this study indicate that the inclusion of animated instruction may be unnecessary given verbal presentations which are carefully designed to provide adult students with highly imageable explanations and examples and which effectively prompt these students to form such internal images. Although some research has indicated that there are conditions under which animated visuals can be effective for presentation purposes, such as occasionally with young children, this effect has yet to be replicated with adults. However, the response latency data indicated that the animated visuals facilitated initial encoding and subsequent retrieval, thus aiding learning. Successful applications of animated visuals with adult populations have been reported when the animation is used as an interactive dynamic (Collins, Adams, & Pew, 1978; Rieber, 1989b; White, 1984). In this study, such an interactive dynamic was used as a cognitive practice activity, and was shown to be an effective influencer of higher-level learning, although no more so than traditional approaches. It is important to note that it is very difficult to distinguish animation's role when used as part of an interactive dynamic, as the experience is largely context specific (Rieber, 1989a). More research is needed to clarify other applications of the conditions under which interactive dynamics are and are not effective. Additionally, the suggested interaction between animated presentations and interactive dynamics which indicated possible interference to learning needs more clarification.

A conclusion of this research is that CBI designers should be encouraged to continue to design creative and innovative interactive dynamics as it appears that the time necessary to design such animated visuals is worthwhile. In contrast, animated presentations can probably be effectively substituted with well-designed verbal presentations, with and without static graphics, which effectively prompt older students (adults) to form internal images. More research is needed in other content areas and instructional situations in order to determine the boundaries of these effects.

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Table 1

Mean Percent Scores and Standard Deviations for the Posttest

		Practice		
Visual Elaboration		Behavioral	Cognitive	None
Static Graphic	Mean	80.5	77.3	64.0
	SD	(28.3)	(32.0)	(36.6)
	n	16	16	16
Animated Graphic	Mean	81.6	70.2	72.3
	SD	(26.9)	(33.7)	(35.5)
	n	15	15	15
No Graphic	Mean	81.2	81.4	71.5
	SD	(30.2)	(28.7)	(33.1)
	n	16	16	16

Table 2

ANOVA Summary Table

Source	*DF*	*MS*	*F*	Probability
(V)isual Elaboration	2	1337.45	1.62	0.199
(P)ractice	2	10073.25	12.19	0.0001*
(V)(P)	4	1813.02	2.19	0.068
Error	660	826.39		
(L)esson Objective	5	2782.82	3.37	0.005*
(V)(L)	10	1051.05	1.27	0.243
(P)(L)	10	771.01	0.93	0.502
(V)(P)(L)	20	764.02	0.92	0.556
Error	660	826.39		

*$p<.01$

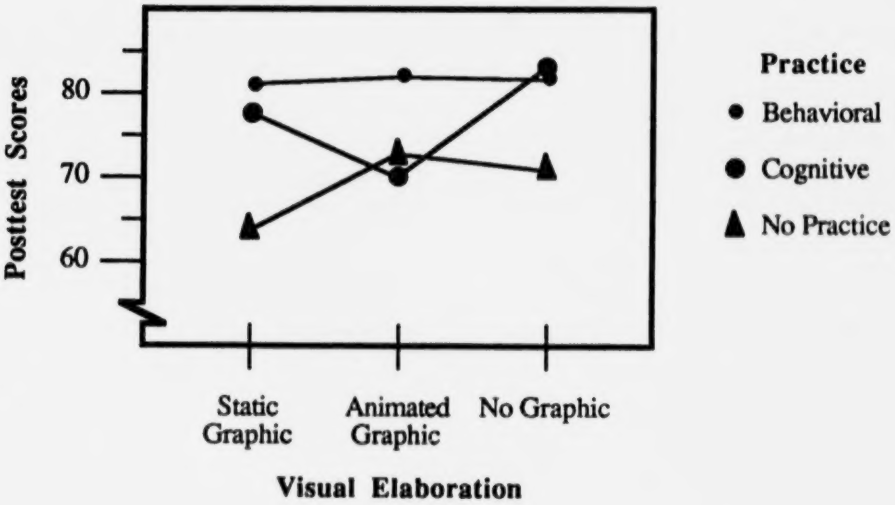

Figure 1. Interaction between Visual Elaboration and Practice.

Title:

Computer Access and Flowcharting as Variables in Learning Computer Programming

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Computer Access and Flowcharting as Variables in Learning Computer Programming

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Computer Access and Flowcharting as Variables in Learning Computer Programming

Research on pre-college programming instruction has often yielded disappointing results. After completing such courses, students frequently exhibit fundamental misconceptions and poor problem-solving strategies (Dalbey, Tournaire, & Linn, 1986). These outcomes suggest that traditional methods of teaching programming in secondary schools may need to be reoriented to better accommodate environments that often differ substantially from college classes. One interest of the present study concerns the provision of unlimited access to computers in programming classes. While the importance of computer access is intuitively apparent, the notion has not been thoroughly researched. On the one hand, it would seem that on-line practice can promote discovery of design principles and procedures (Bayman & Mayer, 1983). On the other hand, the novice's "rush to the computer" may be associated with little program planning and consequently poor techniques and conceptual understanding (Mayer, 1979; Pea & Kurland, 1983; Dalby et al., 1986). From the latter perspective, limited computer access might engage students to a greater extent in planning activities, and thus engender more systematic problem-solving approaches than would occur with unlimited access.

The above rationale raises the additional question of whether planning activities can be facilitated by using flowcharts to specify the program logic and structure prior to writing code. Research on the benefits of flowcharting, however, has been inconclusive (Glorfeld & Palko, 1984; Schneiderman et al., 1982; Brook & Duncan, 1982). Accordingly, as an extension of this earlier work, the present study crossed the manipulation of flowcharting with in-class computer access, thus examining flowcharting effects in (a) the traditional lecture/laboratory setting and (b) a classroom setting replacing on-line time with manual simulation. A reasonable assumption is that when computer access is not an immediate option, students will use flowcharting more effectively as a design strategy. A supplementary question concerned whether gender differences in programming performance would occur under the different flowcharting and computer access conditions. Previous results suggest that females generally perform as well as males at learning to program (Madinach & Corno, 1985; and numerous others), but it could be that different attitudes and learning strategies (Lockheed, 1985) predispose one group to adapt better in less structured (e.g., no flow diagram; unlimited access) settings, and vice versa.

Method

Sample and Design

Subjects were 24 male and 48 female high school students enrolled in four sections of a computer literacy course taught by the second author. All had completed 12 weeks of the 18-week course, but had not yet received any programming instruction. They were assigned at random to four treatment groups arranged by crossing the computer access variable (unlimited vs. limited) with flowcharting (required vs. not required).

Initial analysis used a 2 (computer access) x 2 (flowcharting) x 2 (gender) MANOVA with dependent variables consisting of error recognition, interpretation, programming templates, mental models, programming problem, flowchart score, programming attitude, and flowcharting attitude. Subsequent analysis, incorporating prior academic achievement as a variable, consisted of a 2 x 2 x 3 MANOVA utilizing computer access, flowcharting, and ability group (high, medium, or low) as independent variables.

Course Curriculum and Materials

Five instructional units dealing with introductory concepts in the BASIC programming language were presented in 18 50-minute class periods. Unit I dealt with operational commands, such as RUN, LIST, SAVE, and editing features. Students were also introduced to programming terminology and fundamental concepts, as well as flowcharting techniques. Units II - V presented applications using programming statements LET, PRINT, GOTO, INPUT, and IF/THEN. The posttests described below were administered over a two-day period immediately following the completion of Unit V.

Achievement posttest. The achievement posttest assessed performance on five fundamental programming skills and on ability to utilize flowcharting as a programming aid.

Subtest I, "Error Recognition," presented eight short groups of programming code which contained either a syntax or logic error. Students were asked to find and specify the cause of the error. Items were scored as correct (1) or incorrect (0).

Subtest II, "Interpretation," presented students with four short programs and required them to identify the purpose and output of the code. Students were scored for both their narrative explanations and descriptions of output (1 for correct, 0 for incorrect).

Subtest III, "Programming Templates" required students to write three short segments of programming code which performed a fundamental procedure such as averaging, counting, or evaluating input. Programs were scored as correct in both syntax and logic (2), correct in either logic or syntax (1), or totally incorrect (0).

Subtest IV, "Mental Models," was designed from the work of Bayman (1983) to assess accuracy of students' mental models of statement execution. Students were given common programming statements and asked to describe in a step-by-step fashion exactly what happened when the statement executed. Explanations were scored as correct (2), incomplete (1), or incorrect (0).

Subtest V, "Programming Problem," presented students with a problem for which they had to develop a program. Students first designed a flowchart and then wrote programming code. Flowcharts were scored as correct (3), incomplete (2), incorrect (1), or no attempt (0). Programming score was obtained by scoring individually five routines or templates required by the programming problem (input routine; evaluation of input; use of summing variable; combining a literal string and a variable in a print statement; and recursion) in the same manner as Part III above (2, 1, or 0).

In scoring the posttest, clear rules were developed and strictly followed to ensure objectivity. Also, identification numbers, rather than names, were used in order to conceal subjects' identities during scoring. Internal consistency alpha's ranged from .65 to .86 for all measures.

Attitude measure. Following the posttest, a 15-item attitude survey was administered. Students were asked to respond to such statements as "Programming is fun" by indicating the extent to which (on a Likert scale of 1 to 5) they agreed with the item. Statements related to either attitude toward use of flowcharts or attitude toward programming. Ten additional items were included to gather information on students' prior programming experience, out of class computer access, and so on.

Procedure

Students in these classes had been accustomed to sharing a computer with one or more partners during the prior 12 weeks of the semester. They were told that for this programming unit, a new method of conducting the class was to be tried, and that on-line computer time and classwork requirements would be different depending on the instructional group in which they were placed. The classes were quite willing to cooperate and, after the first few days of instruction, there was never a need to discuss the different methods again.

Treatment began on Unit II, with the presentation of new concepts and statements to the combined treatment groups. After the instructional period, students practiced the statements that had been presented according to assigned treatment procedures. Students in the unlimited-access group worked in the laboratory section of the classroom where a computer was assigned to each individual to use as he or she desired. Members of the limited-access group worked at their desks in the lecture area of the classroom. These students (ranging in number from 7 - 10) shared a single computer for testing their code. Working with partners or in informal groups was not allowed, although both groups were allowed to discuss problems and seek help from other students or the teacher. It was expected that the limited-access group would be more responsive to interaction with the teacher than the unlimited-access group and, consequently, might receive more instruction and attention. To control for this, the teacher did not initiate contact with either group and responded when called on by asking a leading question or making a suggestion rather than supplying the answer.

Half of the students in each of the access groups were required to submit flowcharts with their assignments. The classes were introduced to the technique of flowcharting as an instructional design aid in the first programming unit. Flowcharting was initially demonstrated in a non-programming application and applied to programming when the first statement was introduced. One class period was devoted to instruction in flowcharting and all students participated in exercises involving flowchart creation. The teacher continued to demonstrate program flow using flowcharts and to recommend them for program design. However, only those students in the flowchart groups were required to submit them to fulfill their assignments. The same basic procedures were followed for Units III-IV. Following Unit V, students completed the achievement posttest followed by the attitude survey.

Results

Dependent variables were scores on the five programming achievement subtests, flowcharting score, flowcharting attitude, and programming attitude. All measures, with the exception of programming attitude, were significantly interrelated (Median $\underline{r}$ = .55), implying the use of multivariate analysis of variance (MANOVA) to decrease the risk of a Type I error. The basic MANOVA was a three-way factorial consisting of 2(computer access) x 2(flowcharting) x either 2(gender) or 3(ability) group. A regression solution was used in all multivariate and univariate two-factor analyses to control possible biases caused by unequal $\underline{n}$'s. Initial analyses showed no differences on cumulative attitude score due to either the computer access or flowcharting variable.

Gender as an Individual Difference Variable

Analyses using gender as a grouping variable yielded only one significant effect, the interaction between computer access and gender ($\underline{p}$ < .02). Univariate tests of the interaction, however, were significant only on mental models ($\underline{p}$ < .03): females performed better on mental models in the limited access group ($\underline{M}$ = 53% correct) than in the unlimited-access group ($\underline{M}$ = 34%); no differences were evidenced for males. In general, males scored slightly but not significantly ($\underline{p}$ > .05) higher than females on the various programming subtests.

Ability as an Individual Difference Variable

To examine the ATI involving academic ability, students were ranked according to cumulative grade point averages and were divided into high, medium, and low groups of approximately equal numbers based on those rankings. As would be expected, the ability group main effect was significant in the MANOVA ($\underline{p}$ < .001) and in all univariate tests (high > middle > low). More revealing was the significant multivariate computer-access by ability ATI ($\underline{p}$ < .01), which was also significant in all univariate tests except for programming templates. The consistent pattern was for the low-ability group to perform better under unlimited- than limited-computer access, whereas the opposite tendency occurred for middle- and high-ability groups. Follow-up examination of the five ATIs showed that each pattern was disordinal. Specifically, in each case, the unlimited access mean was higher than the limited access mean for low-achievers ($\underline{p}$ < .05), while the converse pattern occurred for middle- and high-achievers.

The MANOVA also yielded a significant flowcharting main effect ($\underline{p}$ < .05). Univariate tests were significant for mental models and programming problem. However, an examination of group means indicated that the effect was not in the direction hypothesized. Students who were not required to submit flowcharts tended to score higher on all subtests than those required to submit them. On mental models, the no-flowchart group mean was 1.13 compared to the flowchart-required group mean of .80; on the programming problem, the respective means were 1.08 and .65.

Discussion

The present results were inconsistent with some common assumptions regarding the influences on learning programming of unlimited in-class computer access, flowcharting, and gender. Accordingly, different ways of conceptualizing and structuring programming instruction at the precollege level are suggested. First, group means on four of five posttest measures were directionally higher for the limited-access group than the unlimited-access group. While it is clearly helpful to achievement to have sufficient access to computers, imposing reasonable limitations on computer access may encourage students to give greater attention to program design and mental execution of code. This overall interpretation, however, was qualified by several ATI effects. Females performed better under limited access, while males showed the opposite pattern. One possible explanation concerns females' generally lower confidence and greater anxiety regarding computer interactions (Chen, 1986). Thus, a greater proportion of females than males may have found it more comfortable to work without a computer. Given that this effect occurred on only one dependent variable, however, its importance should be questioned. A stronger and more consistent ATI pattern was for low-ability students to perform better with unlimited access, and conversely for middle- and high-ability students. Low-ability students, it would seem, are less able to mentally simulate program execution and therefore become more dependent on immediate computer feedback and concrete contextual cues. Higher-ability students are better prepared to benefit from the added cognitive demands of limited access and to use the increased planning time effectively.

The significant flowcharting effects on posttest scores indicated that students performed better when not required to submit flowcharts. One explanation is that many did not adequately master flowcharting skills. In fact, on a follow-up survey 65% reported understanding it "somewhat" and 19% "not at all." Second, seemingly because of its pictorial orientation and special symbol system, flowcharting appeared to be regarded by many students as an entirely separate task, rather than as a programming aid. Perhaps, similar to how sentence diagramming in English is taught, flowcharting may be more beneficial if introduced after students have acquired a fundamental understanding of programming processes. It is also revealing that over 65% of the flowchart group reported creating the flowchart after having written the associated programming code. These negative experiences undoubtedly contributed to the flowchart group's rating of programming as "more frightening" compared to the no-flowchart group. Gender was not significantly related to either achievement or attitudes. It is noteworthy, however, that in this elective high school literacy course, taught by a female instructor, females outnumbered males by 2:1, a direct contrast with typical ratios (Lockheed, 1985). As Linn (1985) has noted, the main problem for female students has traditionally been lack of participation, not of ability, in programming classes.

The above results suggest three major considerations for the teaching of programming. First, unlimited computer access may be less important than is generally assumed, especially for middle- and high-achievers. Teachers might consider encouraging (or requiring) the latter groups to spend more time designing and mentally simulating procedures away from the computer. Second, if flowcharting is to be useful as a design aid, considerably more time and emphasis should be given to its instruction than is done typically. Poorly formulated flowcharts can only provide weak foundations for developing programs. Third, as other recent studies have suggested, males and females appear to have much the same potential and instructional needs for learning programming. Seemingly, students' increasing exposure to computers in early grades and to positive female role models (as in the present study) will make female participation in programming classes less of a problem over time.

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Title:

Reducing the Density of Text Presentations using Alternative Control Strategies and Media

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Reducing the Density of Text Presentations using Alternative Control Strategies and Media

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Reducing the Density of Text Presentations Using Alternative Control Strategies and Media

A critical process in developing lessons for computer-based instruction (CBI) is to determine the manner in which information will be displayed on the screen. Unfortunately, in many commercial CBI products, the computer's special display capabilities are ignored, much as if the monitor screen were simply an electronic representation of a print page (Burke, 1981; Bork, 1987). The present research addressed this issue in reference to the specific problem of displaying instructional text. The underlying assumption was that reducing the density of text presentations would be effective for improving readability and learning under CBI. In the present study, a "low -density" version of an instructional unit on central tendency was prepared from conventional, "high-density" text by reducing sentences to main ideas and deleting unnecessary modifiers, articles, and phrases.

A third experimental condition was "learner-control" in which individual students were allowed to choose the density level they preferred at the beginning of each of five lessons. Clearly, the issue of learner-control has attracted considerable interest and extensive inquiry among CBI researchers. Although some studies have shown positive results for learner control, recent findings have more often been negative (Carrier, Davidson, & Williams, 1985; Tennyson, 1980). An overall interpretation is that many sudents, especilly low-achievers, lack the expertise to make effective decisions regarding the quantity and type of instructional support to select. On the other hand, learners may be sufficiently perceptive about personal interests and learning styles to judge what *mode* or *form* of presentation best accommodates their needs. Given this rationale, we examined the questions of: (a) What learner characteristics relate to the selection of high- and low-densiy material? and (b) How does learner-control overtext density influence learning and motivation? Other features of the design permitted examination of an extended learner-control strategy that allowed selection of presentaton medium (print vs CBI) in addition to density level, and of aptitude-treatment interaction (ATI's) effects involving reading ability and prior achievement.

Method

Subjects and Design

Subjects were 221 preservice teachers. They were randomly assigned to seven treatment groups arranged according to a 2(presentation mode: CBI or print) x 3(density condition: high, low, or learner control) factorial design with one outside condition, "full" learner control (density and media selection).

Preattitude survey and pretest. This measure consisted of a brief questionnaire to determine subjects' attitudes towards the subject to be taught and CBI. Ratings were recorded on a five-point Likert-type scale, with "5" representing the most positive reaction. For full-LC subjects, an additional item indicated that during the instructional phase they might be asked to study a lesson from either printed materials or from a computer lesson, and to check which of the two modes they would prefer. The unit pretest, administered to all subjects, consisted of 10 items on the material covered in the instructional unit on central tendency.

Nelson-Denny Reading Test. Subjects were administered the "comprehension and rate" section of Form D of the Nelson-Denny Reading Test (Brown, 1976). Comprehension was measured by having examinees read eight paragraphs and answer multiple-choice questions on each. Reading rate was measured by asking them to record the number of the line they had reached following the initial 60 sec. of reading.

Instructional unit. The learning material was an introductory unit on central tendency prepared by Morrison, Ross, & O'Dell (1988). The content was adapted from self-instructional learning modules used in an undergraduate statistics course. For research purposes, the unit was organized into five sections ("lessons") covering the mean, the median, the mode, uses of central tendency measures in different distributions, and positions of central tendency measures in different distributions. Emphasis was on teaching facts and conceptual information that students would need to recall for solving and interpreting problems. A conventional (high-density) print version of the lesson, patterned after the original text (Ross, 1982), was initially prepared. Total length was 18 pages and 2,123 words. Within each lesson the basic instructional orientation involved defining the main concept or idea and then illustrating its application with several numerical examples. Following Reder and Anderson's (1980; 1982) procedure, the low-density version was developed by (a) defining a set of general rules for shortening the material, (b) having at least two judges discuss the rules and rewrite the materials accordingly, and (c) reviewing the material and making changes until consensus was achieved that all criteria were satisfied. The rules employed were:

1. Reduce sentences to their main ideas.

    a. Remove any unnecessary modifiers, articles, or phrases.
    b. Split complex sentences into single phrases.

2. Use outline form instead of paragraph form where appropriate.

3. Delete sentences that summarize or amplify without presenting new information.

4. Present information in "frames" containing limited amounts of new information.

The completed low-density lesson consisted of 1,189 words, a 56% savings relative to the high-density version, and 15 pages, a 17% savings. CBI versions of the high- and low-density lessons were prepared directly from the print materials. Word counts for corresponding low- and high-density versions were identical across print and computer modes. Due to the much smaller display area of the computer screen, it was not possible (or considered desirable) to duplicate the print page formats. Computer frames were thus designed independently, using what were subjectively decided to be the most appropriate and realistic screen layouts. This orientation emphasized organizational devices such as headings, liberal "white space," and standard uses and locations of verbal and symbolic prompts. Each screen provided both back- and forward-paging options. The final versions of the low- and high-density CBI lessons consisted of 49 and 66 frames, respectively. Figure 1 shows one of the high-density frames along with its parallel low-density version.

Insert Figure 1 about here

Attitude survey. A 6-item printed attitude survey was administered to all subjects at the completion of the lesson. Items consisted of statements about the learning experience to which subjects indicated levels of agreement or disagreement on a 5-point Likert-type scale (e.g., 1 = "strongly disagree," 5 = "strongly agree").

Achievement posttest. The achievement posttest (print format) consisted of three sections designed to assess different types of learning outcomes. The first section was labeled a knowledge subtest, since it assessed recognition or recall of information exactly as it appeared in the text. The first 17 knowledge items were multiple-choice questions, each consisting of a statement defining one, all, or none of the three central tendency measures (mean, mode, or median). Eight additional questions asked the student to determine relative placements of the mean and the median in distributions that were exact replications of examples that appeared in the lesson. On four of those items, subjects were asked to write a brief rationale for their answers.

The calculation subtest contained five problems requiring computation of different central tendency measures from new data not used in lesson examples. The transfer subtest consisted of 13 items that involved interpreting how central tendency would vary with changes in distributions or individual scores. Items of this type were not included in the lesson, nor were the underlying principles needed to answer them explicitly stated.

Scoring rules on objective items and calculation problems awarded one point for a correct answer. On interpretative items, one point was awarded for a correct answer and an additional point for a correct explanation. A summary of subtest and total test lengths, maximum points, and KR-20 internal consistency reliabilities is as follows: knowledge (25 items, 29 points, r = .81); calculation (5 items, 5 points, r =.68); transfer (13 items, 20 points, r = .82); and total test (43 items, 54 points, r = .90).

Delayed posttest. The delayed posttest (r =.84) consisted of 13 items patterned after pretest items. Ten of the items tested knowledge definitions and relative positions of central tendency measures; the other three tested computational skills.

Procedure

The preattitude survey, pretest, and reading test were administered during a regular class session. During the learning phase of the study, from 2-12 subjects representing a random mixture of treatments attended an individual session. The classroom used for the CBI condition contained 12 Apple IIe computers. Following introductory instructions and a review of prerequisite information, the learning materials were distributed according to treatment. Full-LC subjects received their preferred presentation mode, CBI or print, as selected on the preattitude survey.

Instructions for all treatments indicated that (a) five lessons would be presented on central tendency; (b) learning was to be self-paced; (c) turning back to reread preceding pages (or frames) was permitted if desired; d) it was permissible to ask the proctor any questions about the task procedure while learning; and e) a posttest would be given following the learning task. Subjects in the two LC treatments received additional instructions indicating that, depending on how much explanation they desired, they could choose between "long" and "short" presentations on each unit. Examples of matched high- and low-density displays were shown to help them make a selection for the initial lesson. In the CBI condition, subjects pressed a key to indicate their preferences; in the print condition they informed the proctor. Density-level selection was repeated at the beginning of each of the remaining four lessons. After subjects completed the last lesson, their finish times were recorded and the attitude survey and immediate posttest were administered. Approximately three weeks later, they were administered the delayed pottest at the beginning of a regular class meeting.

Results

Major dependent variables consisted of four achievement measures (knowledge, calculation, and transfer subtests; delayed posttest), total attitude score, and lesson completion time. In preliminary analyses, no differences were found between treatment groups in pretest performance, pretask attitudes, reading comprehension, or reading rate.

Learner Control Analyses

Full- vs. partial-LC. In an initial set of analyses, outcomes in the partial-LC and full-LC treatments were compared. Inspection of LC treatment means showed them to be quite similar to one another and directionally higher than those for the standard high- and low-density treatments. A 2(LC-strategy) x 2(presentation medium) MANOVA on achievement confirmed the former impression by failing to show any significant effects due to LC-strategies. Nor were significant LC-strategy effects obtained in a univariate ANOVA on attitude scores. The ANOVA on completion time, however, yielded a significant LC-strategy x presentation medium interaction, F (1,69) = 5.71, $p < .02$, and LC-strategy main effect, F (1,69) = 7.73, $p < .01$. Follow-up analyses indicated that in the print condition, no differences occurred between learner control variations, but under CBI, the full-LC group (M = 18.9 min.) took significantly less time than the partial-LC group (M = 29.0 min.). Thus, those who selected CBI completed the lesson more quickly than those who were prescribed CBI (partial-LC), perhaps as a result of having greater experience and confidence in using that medium. Another explanation, supported in the next analysis, is that faster readers were more apt to select CBI than print, thus giving the full-LC group a built-in advantage on the completion rate criterion.

Media preferences. Media selections by the full-LC group were almost equally distributed between print (n = 11) and CBI (n = 13). For exploratory purposes a discriminant analysis was performed using the subgroups as the criterion and the following as predictors: preattitudes, pretest, reading comprehension, and reading rate. Applying step-wise selection, only reading rate was found to be a significant discriminator ($p < .01$). Subjects who selected CBI had higher reading rate scores (M = 271.8) than those who selected print (M =189.3).

Density selections. A 2(LC-strategy) x 2(presentation mode) ANOVA was performed on the total number of low-density selections (out of a possible 5) made by LC subjects. No significant effects were found. Overall means were 3.5 for print and 3.0 for CBI. Thus, there was a general tendency by subjects to prefer low-density materials, regardless of presentation mode. To examine whether certain types of individuals were more likely than others to select low-density material, the number of low-density selectins was regressed, using a step-wise procedure, on the four pretask predictor variables. Again, only reading rate was identified as a significant predictor, ($p < .01$). As reading skills decreased the tendency to select low-density material also declined.

Density Condition X Presentation Mode Analyses

For analyses of achievement and attitudes, data from the full- and partial-LC treatments were pooled within presentation modes. Results for each variable are reported below.

Achievement. The 2 x 2 MANOVA on achievement data showed both main effects to be significant ($p < .05$). In follow-up univariate tests, the density condition effect was significant on all dependent measures except the knowledge subtest. Tukey *HSD* comparisons showed that on the calculation subtest, F (2,215) = 2.88, $p < .05$, the LC group ($M = 3.71$) was directionally, but not significantly, superior to both the low-density ($M = 3.19$) and high-density ($M = 3.27$) groups. On the transfer subtest, F (2,215) = 5.53, $p < .01$, the LC group ($M = 12.33$) had a significant advantage ($p < .01$) over the low-density group ($M = 9.58$) and a near-significant advantage ($p < .10$) over the high-density group ($M = 10.58$). Similarly, on the delayed posttest, F (2,186) = 5.41, $p < .01$, the LC group ($M = 8.30$) was significantly superior to the low-density group ($M = 7.02$), and directionally superior to the high-density ($M = 7.34$) group. None of the comparisons between high- and low-density means was significant. The only significant presentation mode effect occurred on the delayed posttest on which CBI subjects ($M = 7.95$) surpassed print subjects ($M = 7.00$), F (1,186) = 8.61, $p < .01$.

Attitudes and Completion Time

The two-way ANOVA on attitude total scores failed to yield any significant effects. Completion times were longer for CBI ($M = 25.8$ min.) than for print ($M =21.5$), F (1,144) = 4.45, $p < .05$; and for high-density ($M = 26.5$) than for low-density text ($M =21.0$), F (1,144) = 8.60, $p < .01$.

Learning from High-Density Microtext

A collateral research interest was the relationship between student characteristics and learning from high-density microtext. Separate stepwise multiple regressions were performed on criteria consisting of immediate and delayed posttest scores, attitude total score, and completion time. Predictor measures consisted of the pretest, pretask attitudes, reading scores, and, where appropriate, other "criterion" variables.

When immediate posttest scores were treated as the criterion, reading comprehension (simple $r = .51$) was the first predictor entered in the equation ($R^2 = .26$, $p < .001$). Pretest score (simple $r = .26$), which had been expected to be the strongest predictor, was entered on the second step, but made a relatively weak contribution to the equation. No other predictors were entered. Other findings were: (a) no predictor variables were significant in accounting for variance in completion time, (b) pre-attitude score was the only significant predictor of attitude total score, (c) and pretest score was selected on the first step and reading comprehension on the second step with the delayed posttest as the criterion.

Discussion

The results support earlier findings with print material (Reder & Anderson, 1980; 1982), by showing low-density text to be as effective as high-density text on every achievement measure. Importantly, low-density narrative offered the advantage of reducing reading time by 13% in the print condition and by 28% in the CBI condition. Results were supportive of learner-control by showing it to yield significant achievement advantages over standard density treatments. To often, findings from learner-control studies are summarized by some global statement concerning "learner control's" ineffectiveness (or effectiveness) as an adaptive strategy. Such interpretations can be misleading since they fail to distinguish between the many different types of learner-control that can be employed. Specifically, resuslts concerning learner control of instructional support have shown a tendency by low-achievers to make inappropriate decisions (Ross & Rakow, 1982; Seidel, 1975).

In contrast to that pattern, fairly effective meta-cognitive strategies appear to have been used here by both low-achievers and high-achievers in selecting text density. Preferences for high-density materials were unrelated to prior achievement, which is typically a strong correlate of learner-control decisions (Tobias, 1987), but were negatively correlated with reading ability. Poor readers elected to receive greater narrative support whereas good readers opted for the more streamlined, low-density lesson which could reduce reading time, yet adequately (for them) support comprehension. These appear to be pedagogically sound decisions for the stdent groups concerned.

As might be expected (see Clark, 1985), no meaningful differences between presentation media were found on task outcomes. From a practical standpoint, comparing media seems much less important than the selective and systematic matching of instructional strategies to the specific media that must powerfully represent them. The present results suggest that traditional text narrative formats do not serve such purposes for CBI. The availability of low-density text as a standard component or learner-control option in narrative lessons deserve further attention as possibly beneficial alternative.

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Figure 1. Parallel high and low density frames from the instructional unit.

The median corresponds to the middle frequency score in a ranked set of data

Half the scores will be higher
Half will be lower

X f
Hi 50%
Median---
Lo 50%

If N=40 (40 scores), median = 20th score
If N=17, median = 8.5 highest score

Median corresponds to the 50th percentile

Higher than half the scores
Lower than half

The median, another measure of central tendency, is the number that corresponds to the middle frequency (that is, the middle score) in a ranked set of data. The median is the value that divides your distribution in half; half of the scores will be higher than the median, and half will be lower than the median.

X f
Hi 50%
Median-----------------------------------
Lo 50%

It is important to remember that the median is the halfway point in the distribution--in terms of frequencies. For example, if N=40 (meaning that you have 40 scores), the median will be your 20th score (in terms of rank); if N=17, the median will be your 8.5 highest score, etc.

Another way of defining the median is to say that it corresponds to the 50th percentile.

In any distribution, the median will always be the score that corresponds to a percentile rank of 50; it is higher than half the scores, and lower than half the scores.

Title:

The Apple Classroom of Tomorrow Program with At-Risk Students

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The Apple Classroom of Tomorrow Program
with At-Risk Students

A growing number of our nation's students are considered academically at risk. The precipitating circumstances vary from individual to individual, but in a multitude of cases it is a combination of disadvantaged backgrounds and limited resources at home and often at school. Encouragingly, through the design and application of specialized programs such as continuous progress learning, individualized instruction, and cooperative learning, considerable progress is being made in improving the academic performance of these children (Slavin 1988). Offering further hope is the still untapped potential of instructional technology to make powerful educational interventions available to supplement conventional instruction. Such a program, called the Apple Classroom of Tomorrow (ACOT), is the focus of the present study.

The research context is an inner-city elementary school with an enrollment of 900 students, nearly all of whom are black. For these at-risk students, failure and drop-out rates far exceed state and national norms. The purpose of ACOT is to establish a saturated computer environment both to supplement conventional instruction with CBI and to teach applications skills (such as word-processing) to facilitate performance of school tasks. The rationale is that, through successful participation, students will acquire increased motivation, self-confidence, and competence in basic skills and independent learning. Although the program has many different components (CBI, Logo training, software applications), of particular interest to the present research was the use of telecommunications to make one-to-one tutoring of the children by college students both cost-effective and practical.

The ACOT program was initiated in the fall of the 1986-87 school year through a grant from Apple Computer to equip classrooms with microcomputers at the fifth- and sixth-grade levels. Importantly, uses of these computer resources were designed to support specific instructional strategies identified as having high potential to benefit the student population concerned. Specific components are:

(1) Each student and teacher receives a computer to use at school and another to use at home, thus allowing for virtually unlimited computer access for working with CBI programs and practicing applications skills.

(2) Training in basic skills and in using tool software is emphasized.

(3) Parents are integrally involved by being required to attend training sessions and set up the home computer systems. They are also encouraged to work with their children in completing ACOT homework assignments.

(4) Seemingly the most powerful intervention is the assignment, to each student, of a personal tutor who is an education major at a local university. The tutor leaves assignments and writes messages and feedback over an electronic Bulletin Board System (BBS) accessed by modem. This type of application extends existing telephone tutoring strategies, "homework hotlines," and distance learning programs (Butler & Jobe, 1987; Davis 1987; Pedley, 1987; Wood, 1986; Zeller, 1987) by (a) fostering close and long-term relationships between tutors and tutees, (b) maintaining messages and feedback for long-term review, and (c) embedding instructional communications within an

integrated academic program created and delivered through a partnership between teachers, tutors, parents, and university faculty.

Although this computer-saturated program has considerable face appeal, its effectiveness cannot be assumed on that basis alone. Any immediate benefits may be largely attributable to the high levels of individualized attention provided and the newness of the CBI and the BBS resources. Accordingly, extensive and long-term evaluations have been planned to determine participants' activities and attitudes, the program's methodological strengths and limitations, and the influences of component instructional strategies. Studies completed this past year have focused on the BBS tutoring component. This research will be the focus of the present paper.

Program Methodology

Recruitment

In considering needs for tutors, it was decided that college education majors would be ideal candidates given their interest and experiences in teaching. Volunteers were solicited from the Master's of Arts in Teaching Program (MAT) at Memphis State University. This particular group had several compelling reasons for volunteering. One was to learn from firsthand experiences about computers and their uses in schools. Another was to broaden their teacher training by working with the at-risk minority students in the ACOT classroom. A third was to obtain a home computer that they could use for personal work during the school year. A fourth was the opportunity to conduct their Master's thesis studies on one of numerous ACOT-related topics. With these built-in incentives, it was not surprising that we had more volunteers than space could accommodate. The final group of 10 tutors consisted of four males (one minority) and six females, ranging in age from 23 to 47. Their teaching concentrations included science, English, foreign language, social studies, and music.

The BBS System

The host system was a 512 Macintosh with a 20 megabyte hard disk drive and an Apple Personal Modem. One dedicated phone line was used for all incoming calls. The BBS software was Red Ryder Host. Sudents and tutors accessed the BBS using an Apple IIc computer, an Apple Personal Modem, and Apple Access II software. Once on-line, they entered their special code name and were then acknowledged by the system. Next, any messages that had been sent to them since their last access were listed by sender's name and message number. They could then select between menu options allowing them to read, post, or delete messages. The system operator preset a clearance time limit for each group of users. Students and tutors primarily communicated over a "public" bulletin board that anyone could view, but they could also access an electronic mail section to send private messages. In posting a message, the user entered the recipient's name and a brief message title. After typing the message, he/she could choose to send it as it appeared, edit it, or delete it. File transfer was not easily accomplished and therefore was not used.

The Tutoring Model

The tutoring project was initiated by conducting several orientation and training sessions for students, their parents, and tutors. The sessions gave basic demonstrations of how to connect and operate the computer equipment.

Although participants typically had little or no computer experience, they appeared to encounter little difficulty in learning these skills. A second part of the training dealt with the procedures for using the BBS.

Tutoring assignments during the year were primarily activities designed to develop writing skills. One assignment was for the student to write a friendly letter using a format taught in class. The tutor read the letter on the BBS and responded with suggestions about improvements, which the tutor attempted to incorporate in the next draft. This type of interaction was repeated until the tutor was satisfied that the letter met the teacher's criteria. The tutees were graded by the teacher based on the quality of the work and degree of BBS use. Next, the tutors wrote a letter conveying purposeful mistakes to the student. The student's task was to read the letter and identify the mistakes.

A second kind of assignment was used to help students expand their reading and writing vocabulary. Each student constructed an AppleWorks data base containing four categories of information: new words, context sentence, definition, and original sentence. Tutors used the data base to develop learning exercises incorporating those words. In addition to these and other formal assignments, tutors and students were encouraged to use the BBS to share everyday experiences and keep in regular contact with one another.

Research Methods and Findings

Participant groups in the research consisted of 120 fifth- and sixth-grade ACOT students and their parents, teachers, and tutors. Control groups were comprised of approximately equal numbers of children attending matched conventional classes at the same school. The research orientation included formative evaluation of instructional materials and methods to determine how they were working and to identify any needed refinements; and summative evaluation to examine end-of-year outcomes on a variety of performance and affective variables. Some of the studies were time-series designs involving the ACOT group only, whereas others were quasi-experimental comparisons between ACOT and control classes.

The focus of completed research studies include the following: (I) ACOT pre-post gains and outcomes on standardized achievement (CAT) tests, school attendance, and motivation/self-concept measures; (II) the thematic classification of student/tutor messages on the BBS; (III) the influences of BBS activity on keyboarding skills; (IV) modem tutor roles and attitudes; and (V) ACOT activities and the development of writing skills.

A summary of the major findings by study is as follows:

Study I: ACOT students were superior to controls in CAT reading and math performance (Kitabchi, 1987; 1988).

II: (A) Girls used the BBS more than boys, especially for communicating with friends. (B) The BBS was extensively used during the year for exchanging social and academic messages. (C) The quantity and length of messages were not related to students' academic achievement (Ulrich, 1988).

III: (A) Most students developed considerable proficiency at keyboarding over the school year. (B) Keyboarding skill was not related to amount of BBS use or to academic achievement. (C) Teachers reacted positively to students' keyboarding accomplishments, but were frustrated by the lack of a systematic model for teaching those skills (Hester,-1988).

IV: (A) Tutors generally regarded their activities as beneficial to them personally and to the tutees. (B) They felt that a mentoring relationship in which they tutored and encouraged students was more effective than one in which they evaluated students by grading their work. (C) They were frequently frustrated by the difficulty of accessing the BBS due to its single-line connect capability, and by the absence of clearly specificed tutoring guidelines or assignments (Parry, 1988).

V: (A) Writing skills, evaluated through a systematic analysis scheme, were higher on several dimensions (clarity, organization, grammar) for ACOT students than for the control group. (B) ACOT students generally wrote more concise and better organized essays than the controls. (C) Most ACOT students preferred to write using a computer rather than paper and pencil (Woodson, 1988).

Discussion

Although the higher standardized test performances of the ACOT group relative to the control classes are suggestive of positive program effects, these results need to be viewed cautiously. Because ACOT provided numerous and complex interventions, including special attention from the school system and community, it becomes impossible to isolate its effective attributes or distinguish them from Hawthorne-type effects. However, given this promising preliminary evidence, standardized test performance will be closely monitored in future studies. Also, a study to be initiated in the Fall, 1988 will follow-up ACOT grauates as they attend conventional seventh-grade classes at other schools.

Presently, more meaningful evaluation outcomes relate to participants' program activities and the competencies and attitudes acquired in the process. Overall findings clearly supported the viability of the program rationale, particularly the components of intensive computer training and one-to-one tutoring support using telecommunications. Importantly, the children made extensive use of the BBS and computer-based instruction for learning, while becoming skilled users of many tool applications. An especially important educational aspect of the BBS component was the requirement for communicating exclusively through reading and writing. Thus, a student population overrepresented by poor and reluctant readers and writers were directly practicing these skills while conversing on a regular basis with friends and tutors. Despite these positive aspects of ACOT, several major limitations were noted, including (a) the absence of a clear tutoring curriculum or methodology, (b) restricted access to the BBS due to the availability of only a single-line connection, (c) lack of participaton by some children in the ACOT class, (d) the failure to involve parents on a continuous or systematic basis during the school year, and (e) absence of a program-oriented instructional model for teachers.

The new Apple-Link Personal Edition is being used in the 1988-1989 program to create a more powerful and flexible BBS. A major advantage is multiple user access using Telenet or Tymnet dial-up networks. Others are capabilities for real-time interactive responding, uploading and downloading of assignments and feedback, and privacy in tutor-student communications. BBS "chat rooms," which allow up to 23 people to converse in real time, will be regularly used to hold group tutoring sessions. Also, while on-line, students will be able to "meet" other Apple-Link users from all over the country, "attend" forums on computer topics, and access numerous information sources (encyclopedia, weather, news, etc.). Tutoring assignments are also being more carefully planned to achieve a better fit with the curriculum and the distance learning environment. Increased efforts to involve parents and arrange more face-to-face contacts between tutors and students during the school year should build a greater sense of community and stronger relationships among participants.

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Title:

Teaching Science Using Interactive Videodisc: Results of the Pilot Year Evaluation of the Texas Learning Technology Group Project

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TEACHING SCIENCE USING INTERACTIVE VIDEODISC: RESULTS OF THE PILOT YEAR EVALUATION OF THE TEXAS LEARNING TECHNOLOGY GROUP PROJECT

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TEACHING SCIENCE USING INTERACTIVE VIDEODISC: RESULTS OF THE PILOT YEAR EVALUATION OF THE TEXAS LEARNING TECHNOLOGY GROUP PROJECT

Introduction

The new computer-based technologies for delivering instruction are bringing dramatic changes to the classroom. One such technology, interactive videodisc, is being used in the first project of its kind in the nation to deliver an entire full-year physical science curriculum for high school students. The teacher´s role in teaching this curriculum, rather than being limited by the technology, has been expanded. Teachers who teach using an interactive technology find themselves managing groups for cooperative learning, for example, in new ways. They become directors of student learning, as well as mentors and guides. They serve as model technology users to their students. They must integrate computer-based lessons into their normal classroom planning. They need not only be familiar with traditional content and methods in their subject area, but must also be adept at orchestrating lessons containing more varied activities which use technology in ways few teachers feel prepared to handle (Savenye & Hudspeth, 1986).

This paper describes the background, methodology and results of an evaluation study conducted during the pilot test of a semester-long high school chemistry curriculum delivered via computer-based interactive video, the Texas Learning Technology Group (TLTG) project. While findings with regard to student achievement and student attitude will be summarized, the primary focus of this paper is on the findings of the qualitative research study conducted to investigate teacher attitudes and teacher implementation behavior.

Overview of the Texas Learning Technology Group Project

Formation

In 1985, the Texas Association of School Boards´ Board of Trustees responded to the national and state crisis in science, math and technology education by forming a partnership to produce technology-based solutions to school problems. The Texas Learning Technology Group (TLTG) Project is a partnership among the Texas Association of School Boards, the National

Science Center Foundation, Inc. (NSCF) and twelve Texas school districts. It is a non-profit organization, which has several sources of funding, including NSCF, the districts, and the National Science Foundation.

The goals of TLTG, as described in a recent evaluation report (TLTG, 1989) were to:

- develop high-quality, low-cost curriculum projects that integrate new technologies into curriculum delivery systems,
- evaluate the effectiveness of a technology-based curriculum, and
- train teachers in the use of new technologies and provide support to schools implementing these new, technologically advanced curricula (in press).

After consultation with a curriculum committee consisting of educators from local districts, state educational agencies and universities, TLTG determined that its first course would be a complete physical science curriculum, due to the shortage of science teachers and lack of student motivation in physical science. Other committees were formed to develop content outlines and determine objectives, to provide technical assistance, and to outline teacher training needs.

Development of the Curriculum

Although at first an outside company was contracted to produce the curriculum, TLTG soon determined that quality and cost-effectiveness would best be served by hiring its own development staff to produce the courseware. The staff included managers, instructional designers, computer programmers and graphics specialists, a video and marketing specialist, subject matter experts and, physical science teachers. In addition, design documents, including instructional flowcharts, scripts and storyboards, were reviewed by pilot teachers and national award-winning science teachers, physicists and chemists, and university specialists in educational technology, science education, chemistry and physics.

Teacher Training

In accordance with the goals of TLTG, teacher training was planned from the project's inception. Pilot teachers participated in training sessions from one year before the time the courseware was to enter their classrooms in order to prepare them for the many changes a technology-based curriculum would bring to their teaching. On-going training sessions, for which the teachers may receive college or career-ladder credit, are scheduled for one week in the summer prior to teaching, as well as one day during the fall and the spring semesters.

The training sessions, taught by TLTG staff, experienced pilot teachers and university professors and other specialists, are "intended to make teachers more comfortable with IVD technology and enhance their abilities to incorporate a technology-based curriculum into the classroom" (TLTG, 1989, in press). In addition to learning how to operate and troubleshoot the hardware and courseware, teachers learn how to manage their classrooms using the technology, especially how to design lesson plans, and encourage student interaction with the science materials. During the training sessions, TLTG also solicited teachers' feedback regarding their opinions of the courseware and changes they would like to see made in subsequent versions.

Description of the TLTG Physical Science Curriculum

The TLTG Physical Science curriculum consists of one semester each of chemistry and physics, making up the complete state requirement of 160 hours of coursework. It consists of fifteen instructional units, including an introduction to physical science, seven chemistry units, six physics units and one unit on energy resources. The curriculum integrates computer and videodisc-delivered presentations of information, teacher-delivered demonstrations, simulated labs, computer-based practice exercises, content-based computer games, wet labs, and paper-based practice sets. Included with the videodiscs and computer software is a teacher's guide, which contains objectives, pacing chart, script, summary notes, practice sets, wet labs, suggested demonstrations, and a glossary; a student guide, and unit tests.

The TLTG program is designed to:

o Increase students' in-depth understanding and rate of learning of physical science concepts and skills,

- Increase the students' interest in science,
- Show the relevance of physical science to daily life,
- Prepare students for an increasingly technological world, and,
- Prepare students for academic and professional advancement in the sciences (TLTG, 1989, in press).

The lessons are different from many computer-based lessons in that they are designed to be used by the teacher with the whole class, or by students working in small groups, rather than by individual students. The curriculum thus relies heavily on the teacher as manager, leader and facilitator. It is not a "stand-alone" computer-based curriculum.

The courseware is designed to run on an IBM InfoWindow touch-screen computer system (with an MS-DOS compatible or PS 2 computer) a videodisc player, and a 25-inch RGB monitor (so that all students in the class can see the screen).

During the 1987-1988 school year TLTG pilot tested the one-semester chemistry course in twelve school districts. During the 1988-1989 school year TLTG is conducting a full-scale field test in over twenty Texas school districts as well as three national sites, in Indiana, Louisiana and Washington State. This paper describes the pilot-year evaluation of the chemistry course, as well as the design of the field-test year evaluation.

Purpose of Formative Evaluation

The TLTG curriculum has been developed using a systematic process of design modified for interactive video. Formative evaluation is one of the primary stages of the systematic process for developing instructional materials and programs (Dick & Carey, 1985). It is conducted to collect data upon which to base decisions during the revision and improvement of instruction. Formative evaluation data is also typically used in designing subsequent programs.

Formative evaluation addresses questions in three major areas: 1) student achievement, 2) student and teacher attitude towards the curriculum and content, and 3) use of the program in actual instructional settings. As the major stage in its formative evaluation process, TLTG conducted a pilot test during the first year of project implementation.

Pilot Year (1987-88) Evaluation

During the pilot test year there was at least one teacher per district who taught all or most of his or her chemistry classes using the curriculum. In most districts, student achievement data was compared to data from classes which districts had selected to closely match the pilot test classes, but which were using the traditional chemistry curriculum.

The evaluation of the pilot tryout of the chemistry curriculum was conducted by several entities. TLTG contracted with the Educational Productivity Council (EPC), a research group at the University of Texas at Austin, to evaluate the effects of the courseware on student achievement, as well as on certain teacher and student attitudes. TLTG staff members also observed teachers implementing the courseware and solicited teacher critiques of courseware for formative evaluation of units. In addition, university researchers in cooperation with TLTG conducted the study of primary concern in this paper, to measure teacher attitudes towards use of the TLTG courseware and analyze videotaped observations of teacher behaviors exhibited while implementing the curriculum.

Pilot Test Evaluation Goals

Twelve school districts piloted seven units (Introduction to Physical Science, Nature of Matter, Atomic Structure and the Periodic Table, Chemical Bonds, Solutions, Chemical Reactions, and Acid-Base Chemistry) in the Fall semester of the 1987-88 school year.

There were two configurations of the interactive videodisc-based system piloted: seven classrooms had teacher-only configurations, with one workstation and a large monitor for the teacher to use and the whole class to watch; nine classrooms had teacher-group configurations, with five group workstations in addition to the teacher workstation.

Research Questions

The following research questions were investigated:

1. Do students learn more physical science concepts

using the IVD courseware than they do from the classroom instruction it replaces?

2. Do students using the IVD courseware exhibit more positive attitudes toward science and the study of science than non-IVD students?

3. Does the amount of learning differ for students with different levels of verbal and quantitative aptitude?

4. Does the amount of learning differ between each of the two system configurations (teacher-only or teacher-group configuration) and the non-IVD students when students' aptitude levels are taken into account?

5. What are the teachers' perceptions of the TLTG "electronic curriculum" (TLTG, 1989, in press).

Methodology

Data Sources

Twenty-six teachers and 2,560 students in 12 school districts participated in the IVD pilot study. Due to missing student information in some of the student records, 2,297 student records were used in the analysis. Achievement data were also collected on a sample of the students (N = 338) who took physical science from some of the pilot teachers the year prior to the implementation of the pilot program. A sample of control group (non-IVD) students about equal to the number in the IVD pilot study also completed the study instruments.

Teachers administered the achievement and aptitude instruments to the pilot groups during the fall of 1987.

Instruments and Data Analysis

Student aptitude was measured using the Developing Cognitive Abilities Test (DCAT), constructed by Donald L. Beggs and John T. Mouw of Southern Illinois University, administered in September. Quantitative and verbal scores of students were used in the data analysis.

Student achievement was measured by the High-School Subject Tests, Physical Science Test, developed by Scott, Foresman and Company, 1980.

Students' attitudes regarding their intention to enroll in elective science classes, were measured by the High School Science Courses Questionnaire, based on Ajzen's and Fishbein's Theory of Reasoned Action. This questionnaire was administered in May of 1988 to a subset of students from the pilot and control classes in five districts.

Teacher perceptions toward the curriculum were measured using an attitude questionnaire developed for the study and administered during the April, 1988, teacher training session.

Videotaped classroom observations. Several of the pilot teachers were videotaped using the curriculum with their classes, and these videotapes were subjected to microanalysis of the teacher behaviors observed during use.

Results of the Pilot Evaluation

Findings in the areas of student achievement, student attitude toward science and teacher perceptions of the curriculum were reported in detail by TLTG (1989) in its evaluation report and in a report prepared for TLTG by the Educational Productivity Council and will be briefly summarized here.

Findings in the areas of teacher attitudes toward use of the curriculum and preliminary results of the analysis of videotaped classroom observations will be presented in detail in this paper.

Student Achievement

Student achievement data were analyzed by IVD group versus control group, IVD students by quantitative and verbal aptitude, as well as IVD teacher-only configuration with control, and IVD teacher-group configuration with control. These data indicated that, in general, the effects of using the IVD curriculum were positive, however the results were complicated, and varied considerably by teacher and other factors.

In general, IVD students achieved higher scores than non-IVD students. In fact, the average IVD student performed better than 63% of the control students. These differences were not uniform, but were greater for low-ability students, especially low verbal ability, with these students outperforming 68 to 79 percent of the low-ability students in non-IVD classrooms.

The greatest differences in achievement were found between low-ability students in the teacher-group configuration and low-ability students in the non-IVD classroom.

Student Attitudes

IVD students indicated a greater degree of intention to enroll in and elective science course than control students. Of particular interest is the finding that of students who had previously failed a science course, those in the IVD group indicated a greater intention to enroll in science than their counterparts in the control group (EPC, 1988; TLTG, 1989).

Teacher Attitudes

Teacher perceptions of curriculum. Nineteen of the twenty-five teachers completed an "implementation and use" questionnaire during the spring teacher training session in April, 1988. All of the teachers indicated that they liked using the curriculum, with 14 agreeing strongly with the statement, and five agreeing.

Fourteen of the teachers indicated that it was easier to teach using the IVD curriculum than it was to use their traditional curricula.

All of the teachers indicated that they used supplemental materials, such as their own activities and worksheets, in conjunction with the curriculum. Six of the teachers said they used other materials 10% of the time, five teachers said they did so 20% of the time, three 30% of the time, one 40% of the time, 2 50% of the time, and 1 60% of the time. Some of the teachers indicated that they did not use some parts of the TLTG curriculum. For example, six teachers said they did not use some of the wet labs, while four teachers said they did not use some practice sets.

All the teachers felt that their students had learned more using the TLTG curriculum than they had learned in previous years. The reasons they gave for this included: the TLTG curriculum provided more opportunities for participation and interaction, the material was more stimulating and interesting to students, teachers saw more enjoyment and willingness to work on the part of the students, and the information was provided in a variety of formats.

All but one of the teachers indicated that their students liked learning chemistry by using the TLTG curriculum, stating as reasons, for example, that students know they've learned more than non-IVD students, that the visuals helped them understand concepts, that they could participate more, that it was different, and that it stimulated students' interest.

With regard to what students liked the best, most (15 of 19) teachers stated that the students liked the computer and videodisc-based games and simulations best. Teachers also mentioned that students liked the small-group activities, the teacher-pupil relationship, the visual stimulation, the electronic instruction (2), the immediate feedback, sound effects, particular units and topics, and practical applications of the content.

With regard to the major differences for the *teacher* in using the curriculum, teachers mentioned a greater workload during this first year (10 of 19), more positive interactions with students (7), that it made teaching less stressful, some said it required more preparation time while others said less, students learned to help each other, and that it made the teacher more of a manager.

Analysis of Videotaped Classroom Observations and Staff Visits to all School Districts

During the pilot year, five teachers were videotaped conducting their classes using the TLTG curriculum. Preliminary microanalysis has focused upon the behaviors of a sample of fifteen minutes each of the classes of two of these teachers. These teachers were selected because they were both using the courseware with a whole-class for the full hour of class. The other teachers were using the courseware for only a few minutes or were using the systems to do small-group labs. Follow-up analyses are planned with the other classes, focussing upon student behaviors.

When using the teacher-led portion of the curriculum, teachers can comment or ask questions about the content presented when the system pauses on a frame. These pauses occur at regular intervals (approximately every 30-40 seconds) and are often accompanied by a text definition or question.

Teachers can also control system pauses by touching a "STOP" icon on the screen. Teacher behavior during a program or teacher-initiated pause was coded for analysis. Pauses are initially coded as to whether they are teacher or program-initiated. Some examples of codes include the following:

Teacher Statements:

EX - Teacher extends the information presented by the TLTG system to new information
PA - Teacher paraphrases the information presented by the system in own words
D - Teacher directs the student to do some action (for example, to take out a piece of notepaper, or to write down a vocabulary word)
EM - Teacher emphasizes key information presented by the system, by cueing the students, for example, by telling them to notice some key attribute of a concept.
DES - Teacher simply desribes what is on the screen

Teacher-Initiated Questions of Students:
(Coded first by whether they are asked of whole class or of an individual student)

REC - Teacher asks students to simply recall information just presented by system
S.Ex - Teacher asks students to tell their own examples of the information just presented, i.e. examples relevant to their own lives
EX - Teacher asks students a question which extends the information presented to new concepts, information or examples
HOW - Teacher asks students how a phenomenon or process presented by the system occurs
WHY - Teacher asks students to explain why a phenomenon or process occurs

Feedback to Student Responses to Teacher-Initiated Questions:
(several types can be combined)

KR - "Knowledge or Results Feedback" - Teacher tells students whether their response is right or wrong
KCR - "Knowledge of Correct Results" - Teacher tells students the correct answer
I - Teacher provides information in the feedback

Student-Initiated Comments and Questions:

QU - Student asks teacher a question (often answered by the teacher in the form of another question and then feedback to student's answer)
COM - Student comments on something teacher said
ANS - Student answers the teacher's question

Based on teacher observations and a preliminary analysis of data, teachers, as a rule, made statements about the content or asked questions when the system paused. Teachers rarely used the stop icon to stop the program themselves, and when they did, it was usually done to repeat a video special effect, rather than to clarify a point.

When commenting, teachers generally paraphrased what was just presented, emphasized main points, and extended the information. When asking questions, teachers usually asked students to recall what was just covered, remember prior information, and apply the knowledge to new situations. When an answer was posed by the system, teachers repeated the question and then evaluated the student answers. Since an answer screen usually followed a question screen and sometimes included feedback in response to an input, students were often getting feedback twice.

There appear to be two types of teaching styles, one that concentrates on dispensing information and one that focuses on seeking information from the students. Teachers who are dispensers of information spend the majority of class time clarifying, paraphrasing, or extending the information provided by the courseware. They do not ask many questions and, in some cases, do not even solicit answers from questions posed by the system, preferring, instead, to answer the questions themselves or tell students that they will find out the answer. Teachers who are seekers of information spend much of the class time asking students to recall what they've just seen and heard, to apply that information to different examples, or to make inferences about a situation by connecting the new information to prior knowledge. These teachers also comment on the material, so much information is exchanged between teacher and students.

Plan for the Field Test Year (1988-89) Evaluation

A new evaluation plan was formulated for the field test year of the TLTG evaluation (1988-1989). A team consisting of TLTG staff members and university researchers involved are collecting data regarding student achievement on objectives-based and standardized achievement tests, and regarding student intention to enroll in science courses in the future. This electronic curriculum, however, relies heavily on teacher management, integration, and delivery. Since it is not a "stand-alone" individual-instruction curriculum, actual classroom implementation data are critical in order to evaluate the real effects of the interactive videodisc science curriculum.

Implementation Study

Data regarding the actual on-site implementation of the TLTG field test curriculum are being collected to answer the following major questions: How are the students and teachers using the curriculum and how do they feel about using the curriculum? More detailed questions include:

1) What are the student and teacher attitudes towards specific instructional design aspects of the electronic curriculum? For example:

   Students - What do students like and dislike about the curriculum? What do students feel helps them the most? What do they feel confuses them? What makes this curriculum unique to them?

   Teachers - What do teachers like and dislike about the curriculum? What do they feel helps students learn the most? How do they feel teachers should be trained to use this type of electronic curriculum? What do they want to learn now about using it? How do teachers believe their classroom role are changing?

2) How are the teachers actually implementing the electronic curriculum in their classrooms? For example,

   What do teachers do as they use the curriculum with whole classes, with small groups and in incorporating the curriculum with wet labs? What do teachers use and not use in the curriculum, and what do they add to it?

   Other questions related to teacher behaviors include:

   A) - What content are the various "electronic delivery" and "control group" teachers teaching? Does the content differ between or within groups? If so, how?

B) - What activities built into the curriculum do teachers use? How do these differ between the teachers who are using the teacher-only workstation for presentation of instruction, and those who have several small-group workstations? How do the teachers in these two configurations handle the wet labs and simulated labs, as well as computer and teacher-delivered practice?

The implementation and attitude data are being collected using several methods: videotaped classroom observations, and student and teacher questionnaires and interviews. To summarize:

Data sources -	Teachers in all thirty selected "experimental" field test classrooms, students in a sample of about six of these classrooms (approximately 180 students).
Instruments -	Student and teacher questionnaires; interview protocols for teachers and students; analysis protocols for videotaped observations.
Procedures -	Administration of student and teacher questionnaires at the end of each semester; teacher and student interviews using established protocols; videotaped observations conducted in sample of classrooms throughout the field test year.

Discussion/Recommendations

This physical science curriculum is unique in the nation. It is the only full-year science curriculum to be delivered by the teacher using interactive videodisc technology in both whole class and small group configurations. This paper described the methodology and results of the pilot evaluation of the TLTG curriculum, conducted during the 1987-1988 school year with over 2000 students and twenty-five teachers in twelve school districts in Texas. The plan for the field test evaluation, being conducted during the 1988-1989 school year with over five thousand students and thirty teachers in four states, was also described.

The effectiveness of the interactive videodisc-based curriculum in teaching chemistry to high school students was demonstrated. Evaluation results indicated that students who used the TLTG curriculum generally learned more than students in control-group classes who learned chemistry using traditional methods, as measured by a standardized science achievement test. It was noted, however that results were not consistent for students of varied verbal and quantitative abilities. Both the achievement data and the teachers' perceptions indicated that the IVD curriculum seems to be more effective with low-ability students.

Achievement varied considerably by teachers. Questionnaire data and preliminary analysis of videotaped classroom observations indicate that the teachers' implement the curriculum very differently. For example, two basic teaching styles appear to be used with the curriculum. Some teachers seem to simply add information to the TLTG presentations during the "pauses", while other teachers seem to use these pauses to ask students questions, provide them with feedback, solicit student-oriented examples of phenomena learned about, and initiate discussions. It is hoped that during the field test year, the qualititive study will yield data regarding teacher behaviors that are most effective when using a teacher-managed electronic curriculum, such as this one.

The pilot evaluation results indicate that teachers have positive attitudes about using the TLTG videodisc-based curriculum, and that they feel their students are learning more, and like learning better, when using the electronic curriculum. Teachers indicated that using the curriculum has changed the behaviors they engage in, as well as their role in the classroom. They also indicate that students particularly enjoy the interactive, visual-based nature of the curriculum, especially the games and simulations.

Feedback from the teachers was a key factor in revising the design of the TLTG courseware. Teachers indicated that they want the technology to be as transparent as possible, so they can concentrate on the content, rather than the technology. To this end, several features have been designed into the program.

One feature is a user program, which allows teachers to load, run, and erase software and diagnose technical problems via a menu. This program permits teachers to use the system without having to know DOS structure or commands.

Another feature is a menu system which promotes smooth navigation through the courseware and easy access to lessons or practice activities. The main menu titles are related to topics, with each topic branching to submenu titles tied to objectives. Since teachers may not get through a whole lesson in a period or may want to review parts of a lesson, a user control feature was designed to allow teachers to skip ahead in small chunks. To let teachers know where they are in the system, they are told which section was just completed and what section is next. They can continue or go to the main menu.

In response to teachers′ request that the program pause often to allow them to reinforce points or check for comprehension, the system is programmed to pause at regular short intervals, such as when a new concept or term is introduced. Text statements or questions are provided whenever the program pauses to cue teachers about what should be discussed or to allow students to take notes about the information. Since student attention was observed to fade after about two minutes of linear video, the video sequence rarely runs for more than a minute.

Because teachers are evaluated on how often they provide constructive feedback to students, they preferred to inform students about the correctness of their responses, rather than the system. Consequently, the teacher-led portion of the curriculum, with the exception of the teacher-led practice activities, does not include many places where an answer is entered and, therefore, evaluated. However, each question screen is followed by an answer screen.

The pilot year evaluation of the TLTG curriculum has several implications for teacher training for classroom use of technology. Since teachers have a great need to become comfortable with the technology as quickly as possible, it is recommended that they have a lot of hands-on time with the IVD system. TLTG hands-on sessions during teacher training, for example, now include experiences with using the videodisc player, loading and running the software, breaking down and setting up the equipment, previewing the IVD instruction, and planning lessons.

To demonstrate the adaptability of the system to different teaching styles, it is advisable to show different teachers teaching with the system. TLTG, for example, invites experienced teachers to show new project teachers how they teach using the curriculum. If it can be shown that certain teaching styles are more effective than others, recommendations can be made to teachers about what works when teaching with the courseware.

Since preliminary reports indicate that the IVD system works well with students that have learning problems, teachers should be given information about how they can use the courseware effectively with this target population.

Finally, it is recommended that in evaluations of videodisc-based curriculum, plans be made to include multiple sources of data collected over a period of several years. The TLTG curriculum is unique not only in its design and goals, but in the scope of the field test currently being conducted. Results of the field test will not only be useful in designing computer-assisted interactive video for science instruction, but for developing recommendations for implementing other interactive video curricula in the schools.

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Title:

What Do Teachers Need to Know about Instructional Media in the Computer Age?

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WHAT DO TEACHERS NEED TO KNOW ABOUT INSTRUCTIONAL MEDIA IN THE COMPUTER AGE?

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WHAT DO TEACHERS NEED TO KNOW ABOUT INSTRUCTIONAL MEDIA IN THE COMPUTER AGE?

Introduction

Most teacher credential programs nationally include training in use of technology: such training is in many cases mandated. Accreditation requirements also often dictate the inclusion of such training. A recent task force of the Association for Educational Communications and Technology has recommended that instructional technology skills and knowledge be included in teacher training.

Yet there is little agreement as to what such training should include. Trends in technology use in education are reflected in the change of the field's very name, from "audio-visual education" through "media education" to the current name, "educational technology." Many university courses have remained in the dark ages by continuing to teach student teachers old technologies which are no longer useful in the field or to teach skills which are no longer relevant, while ignoring technologies, for example, like computers for graphics, or interactive video, which are changing the nature of U.S. education.

There is relative agreement that the use of technology in classrooms can and will change the role of both teachers and media specialists in the schools. Technologists have stressed the teaching of principles of technology use in addition to practices (Gagne, Briggs, & Wager, 1988; Heinich, Molenda & Russell, 1985; Knirk & Gustafson, 1986). Such principles, for example, those involved in selecting appropriate media for given objectives and situations, can be effectivly taught in basic technology courses (Higgins & Reiser, 1985). Other technologists have noted that technology training and use must take into consideration the realities of school situations (Heinich, 1984.) All agree that technology training must continually change to reflect the impact of new technologies. It also is clear that teacher input and "ownership" as well as administrator support are critical in successful use of educational technology.

This paper describes the results of a research study which investigated teacher training needs related to effective use of technology in the classroom. The study was conducted to help improve a state-required, 1-credit media competency course taken by approximately 250 teacher credential candidates per semester at a major California university. The course is offered in several formats, normally once a week for six weeks, or two weekends, or in shorter classes over eight weeks. The course introduces teachers to systematic design of instructional materials; how to write student learning objectives and lesson plans based on Gagne's (1977) nine events of instruction; media equipment operation; production of dittos, overhead transparencies and laminated visuals; media selection, basic instructional video production; and an introduction to educational computer software evaluation.

Methodology

Questions

Data were collected related to the current and anticipated technology training needs of teachers in classrooms in a large California metropolitan area. Data were collected to answer questions in the following areas:

1) Entry-level technology skills of teacher credential candidates. What technologies do credential candidates come into their programs knowing about? What instructional materials, such as videotapes and overhead transparencies, have they produced? What percentage of them already know how to operate certain equipment, such as 16mm projectors and microcomputers?

2) Final evaluations of the skills they learned in the media course by students finishing the course. What do credential students perceive as the most, and least, valuable skills they learned? What did they enjoy the most, the least, and why?

3) Perceived needs of new teachers in the field. What technology related skills, which new teachers learned in their credential programs, do they feel help them teach most effectively? What do these new teachers wish they had learned about technology?

4) Perceptions of teacher education leaders. What do teacher educators believe teachers should learn in order to teach effectively using technology?

Procedures and Instruments

Data were collected using surveys, primarily in teacher education courses at a major university campus and at field-based education sites.

Survey of Media Skills and Opinions of Incoming Teacher Credential Candidates. As part of the normal data collection procedure for the course (EDTEC 404) during the spring semester of 1988, 161 teacher credential candidates completed a questionnaire regarding their experience with using and producing media materials on the first day of their attendance in the course.

End-of-Course Evaluations. During both the fall, 1987, and spring, 1988 semesters, 467 teacher credential candidates completed an end-of-course questionnaire to determine the students' perceptions regarding the skills and knowledge about instructional media which they learned in the course.

Opinions of New Teachers at the End of Their First Year Teaching. Twenty-two of twenty-five first-year elementary teachers participating in a new teacher retention project completed a questionnaire regarding their perceptions of the value and utility of the media skills they learned in their teacher preparation program.

Opinions of Teacher Education Leaders. Seven leaders of the elementary teacher education blocks completed a questionnaire regarding the educational media currently available in the schools, the utility and value of what their credential students were learning about media, and their opinions regarding what teachers need to know about instructional media now and five years from now.

Results

Survey of Media Skills and Opinions of Incoming Teacher Credential Candidates. Of the 161 students who completed the pre-course questionnaire, 103 (64%) had some experience producing instructional media, while 59 (37%) did not. Of all 161 students, most had produced dittos (136, 84%), and 43 (27%) had produced overhead transparencies. Many students (29, 18%) had also produced laminations and flyers or brochures.

Of these students, 124 (77%) had used computers, while 30 (19%) had not. The software most commonly used was a word processor (82, 51%), followed by entertainment games (60, 37%) and educational games (49, 30%). Many students (40, 25%) had used a programming language. Some students had used other types of software, such as spreadsheets and data-base packages, as well.

When asked how these preservice teachers hoped to use what they learned in the media course, half the students indicated they hoped to enhance their teaching by using media as teaching aids, 34 (21%) mentioned they would produce instructional media and visual aids, and 15 (9%) hoped to become mroe proficient at use of equipment.

End-of-Course Evaluations. Final course evaluations indicated that 68% of the 476 students who completed the evaluations strongly agreed or agreed that they liked the course, while 86% said they would use what they learned in the course in their teaching. They mentioned such examples of uses as overheads (51, 11%), video (48, 10%) and dittos (41, 9%).

Students indicated that they felt learning to produce dittos (206, 43%) and overhead transparencies (146, 31%) were the most useful skills they learned, followed by video production (95, 20%), followed by media selection (89, 19%) and lamination (74, 16%). They perceived video (121, 25%) and lamination (67, 14%) as the least useful skills for their teaching.

The topic students enjoyed the most was video production (282, 59%), followed by the "hands-on" experience (70, 15%), computers (39, 8%), and lamination (28, 6%). Reasons they gave for their choices were that these topics were fun (123, 26%), they enjoyed working in groups (45, 9%) and the creativity involved (41, 9%). Topics students enjoyed the least were the lectures and theory (87, 18%), dittos (33, 7%), and media selection (26, 5%). They indicated they did not enjoy some topics because they were boring or redundant or because the limited time in the course made it difficult, frustrating or unenjoyable to learn these topics.

Opinions of New Teachers at the End of Their First Year Teaching. The twenty-two first-year teachers described the media they had used and produced during the past year. Dittos were the most commonly used medium, with 18 (82%) of the teachers having used them, and 17 (77%) having produced them. Other commonly used media were filmstrips (18, 82%), videotapes (17, 77%), audiotapes (17, 77%), and overheads (13, 59%). Teachers reported having produced laminated pictures (16, 73%), overheads (9, 41%), mounted pictures (7, 32%) and photocopies (4, 18%). Only 2 of the teachers (11%) had produced videotapes or audiotapes.

Computers were used in the classrooms of 13 (59%) of the teachers, mostly for educational games (11, 50%), word processing (6, 27%), entertainment games (6, 27%), and CAI programs (6, 27%).

These new teachers felt the most useful media skills they had learned were using the thermofax, lamination, and dittos (4, 18% each), followed by overhead transparencies, and using the 16mm projector (3, 14% each). Least useful was video (2, 11%), Two teachers (11%) said all skills they learned were useful.

The new teachers most wanted to learn about computers (9, 41%), video (4, 18%), and 16mm film projectors (2, 11%). Other topics mentioned were videodiscs and interactive video, slides, tapes, and telecommunications.

When asked how educational technology would change teaching in five years, these teachers mentioned that it would expand students' experiences, help individualize learning, and provide help through new communications media (7, 32%). Many also said there would be more "high technology" and more computers (7, 32%), and that technology would make it easier for teachers to manage and organize instruction (4, 18%).

Opinions of Teacher Education Leaders. The seven teacher education block leaders indicated that all of their field site schools (about ten elementary schools) had 16mm projectors, ditto machines and video recorders, and that most had video cameras, thermofax machines, opaque projectors and 35mm slide projectors.

All teacher educators indicated that they teach objective writing and lesson planning, with a five or seven-step clinical model, and most agreed that they preferred these topics not be taught in the media courses, however they did indicate that the media courses should "mesh" with what is taught in lesson planning.

The teacher educators indicated that in a media course teacher credential students should be taught selection and management of media, computer skills, video use, basic equipment operation and how to use blackboards and other visual media.

In five years they felt teachers would also need to know how to use microcomputers, the management and creative use of technology, strategic planning, grant-writing, how to get equipment and curriculum alignment skills

Discussion

The results of this study indicate that both preservice and in-service teachers value learning about production and use of media and materials commonly available in their schools, such as blackboards, dittos, overheads, mounted pictures, laminations, and use of projectors. Yet, it appears from the pre-course survey that many students already have learned these skills before they enter the required media course. Since the skills are perceived as valuable, they should still be addressed, but there are alternative means for teaching these skills. Self-instructional modules, with test-out and mastery tests, would be one method for providing students with these skills, while leaving valuable class time to pursue topics students indicate are important or very enjoyable, but which are not given enough time in the brief required course, topics such as media selection, and use of video. Topics which students already know, such as dittos, could be addressed in terms of lesson planning in the teaching methods courses.

As a result of these results, several revisions were recommended for the EDTEC 404 course. Information about use of chalkboards and other visual presentation media was added to the course. It was recommended that class time not be spent on objectives and lesson plan writing, with students being able to write objectives and lesson plans for media use and selection using any of the formats they used in their methods courses.

While computer skills were mentioned as being valuable both now and in the future by all participants, the state-mandated three course educational computing sequence will provide students with intense hands-on experience with computers for instruction. It was recommended that the unit on video be expanded to allow students time to accomplish mastery and achieve more satisfaction with the basic video production skills. It was also recommended that the CAI software evaluation unit be replaced by a "new technologies" unit, introducing students to such technologies as interactive video, CD-ROM, and telecommunications, and such a unit was developed and is being implemented.

With the great need for teachers who are adept at performing the multiple roles required of them when they use the power of technology in their classrooms, instructional media technology courses can provide an opportunity for teachers to become "empowered" themselves. This study indicates that preservice, and inservice teachers and their educators recognize the dual need to be skilled at basic media use, while preparing themselves to skillfully use the new technologies to enhance their students' learning.

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Title:

A Short Note on Rules and Higher Order Rules

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A Short Note on Rules and Higher Order Rules

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Having introduced the concept of higher order rules in our research over two decades ago, it is truly gratifying to see these concepts playing such a central role in contemporary thinking and research on cognition. (Back in the 1960's and 1970's, most leading researchers tended to view higher order knowledge as the integration of components - either of S-R associations or of lower order rules.) For example, Perkins and Salomon's (1989) arguments to the effect that both domain specific and content independent knowledge are needed to explain cognitive behavior falls in this category as does Brown, Collins and Duguids's (1989) argument that "culture" has as significant an effect on such behavior as does explicit information.

While this is not the place to develop such issues, some brief comments and cautions seem in order: Perkin's and Salomon's analysis suggests that one can usefully distinguish knowledge that is domain dependent and knowledge that is domain independent. In effect, they too agree that general cognitive skills (higher order rules) operate on specific knowledge (lower order rules). It is important to note, however, that structural analysis (an extended form of cognitive task analysis) demonstrates that *both* kinds of knowledge can be derived from specific content domains. The major difference is that lower order rules are derived directly from specific domains (and represented as lower order rules). Higher order rules are derived indirectly via structural analysis of rules obtained at earlier stages of analysis (see Scandura et al, 1974, 1982, 1984).

Higher order knowledge, historically, has been viewed as content independent (e.g., Polya, 1960) but, in fact, such independence has always been a matter of degree. Compare Polya's (1960) informal discussion of heuristics and Scandura, Durnin and Wulfeck's (1974) analysis which represents Polya's heuristics as explicit higher order rules. Empirical tests and computer simulations have demonstrated both the validity and precise scope of applicability (i.e., transferability) of such rules. Indeed, it is very hard to come up with knowledge which is completely independent of content. Even means-ends analysis (e.g., Newell & Simon, 1972), for example, cannot be uniformly assumed as a common method for solving problems. Earlier research empirically demonstrates its lack of uniform availability (e.g., Scandura, 1971, 1974, 1977, esp. pp.248-50). All higher order knowledge, except for a very simple goal switching control mechanism, appears in some degree to be tied to content.

The importance of cultural (or incidental) knowledge in cognitive behavior can be viewed in a similar manner. It is not that some knowledge cannot be represented explicitly. It is simply that identifying such knowledge is more difficult. For example, it is difficult to reduce the acquisition of Piagetian conservation behavior to instruction on simple rules -- because the knowledge associated with concrete operations is so relatively complex and has such a fundamental impact on the behavior of young children. This does not mean, however, that such knowledge cannot be made explicit. An example of this is Scandura and Scandura's (1980) analysis of Piagetian conservation in terms of explicit higher and lower order rules.

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Title:

Satellite Communications and High School Education: Perceptions of Students, Teachers and Administrators

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TITLE: SATELLITE COMMUNICATIONS
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SATELLITE COMMUNICATION AND HIGH SCHOOL EDUCATION

Perceptions of Students, Teachers, and Administrators Toward the Use of Satellite Technology for Distance Education

Communications satellites in geosynchronous orbit above the earth in a horizon-to-horizon band called the Clarke Belt are routinely used to send televised high school courses to schools throughout the United States. Courses such as calculus, physics, and Japanese are being uplinked and relayed by satellites to high schools dispersed hundreds and even thousands of miles from originating sites. These courses are a regular component of the curriculum of the schools where they are received, even though students usually never see their "satellite" teacher or meet in a traditional classroom situation (Barker and Bechner, 1986).

Use of satellite technology for the delivery of regular high school course work is projected to increase as rural schools continue to decline in enrollment, and as standards for the approval of school curricula become more demanding (Barker, 1987). The U.S. Congress has even approved $20 million for the development of the STAR SCHOOLS Program which will fund the development of regional satellite uplink systems. The purpose of these "satellite star school centers" would be to deliver mathematics, science, and foreign language courses to any school where such courses were needed (Federal Register, 1988).

Purposes of the Paper

This paper will discuss three research studies evaluating the use of satellite technology when it was used for the delivery of high school courses. These studies were completed during 1988.

STUDY #1: This study evaluated the perceptions of school superintendents concerning the use of satellite technology to deliver high school courses for credit. Four research questions were examined.

1. What was the current status of the use of satellite technology in their school?
2. What were the attitudes held by superintendents toward the use of satellites to deliver high school courses for credit?
3. What were their school's immediate, short-term plans for the use of satellite technology?
4. How should satellite courses be administered?

   Specifically, what courses are needed, how long should courses last, how should courses be graded, and how much should satellite courses cost?

Superintendents were given background information about satellite technology in the survey form they completed. Two follow-up mailings were sent to non-responders to ensure a high rate of return. All 436 superintendents employed in Iowa during 1988 were sent the survey.

STUDY #2: Currently, several organizations are offering satellite courses for credit. The largest, the TI-IN network which originates its courses near Houston, TX, offers a nearly complete high school curriculum, and a considerable number of enrichment activities to supplement its courses for credit. Over 200 schools in 15 states subscribe to the TI-IN satellite network, and enroll their students in TI-IN courses (Barker, 1987).

Since the TI-IN network offered the most comprehensive secondary school program using satellite technology, its students were targeted for Phase II of this project. Twenty-four school districts from a half dozen states (Texas, Iowa, Kansas, West Virginia, Michigan, and California) were randomly selected from a list of TI-IN subscribers. The superintendents of these schools were called and asked if they would allow TI-IN students to respond to an anonymous questionnaire dealing with their opinions about learning over the satellite network. Eight research questions were used as the basis for the development of the questionnaire sent to these students.

1. What are the characteristics of students enrolled in satellite courses?
2. Why have students elected to enroll in satellite courses?
3. What are the students' perceptions of the strengths and weaknesses of interactive satellite instruction?
4. How do students view the difficulty of satellite courses?
5. From the students' perspective, do satellite courses offer other benefits beyond course content?
6. From the students' perspective, do satellite courses provide a sufficient level of interaction between students and teachers?
7. What ideas do students have that would improve satellite instruction?
8. To what degree do students support satellite instruction?

STUDY #3: Since distance education in general, and satellite course delivery specifically, have implications for both teachers and administrators, the third part of this project was designed to obtain opinions from leaders of teacher and school administrator organizations. Specifically, the current presidents of the fifty state teacher organizations and the presidents of the fifty state associations of school administrators were questioned concerning their attitudes toward the use of satellite technology to deliver high school courses.

A questionnaire was sent to each of these leaders. The questions included in the survey produced data related to these four research questions.

1. Is the use of satellites to deliver courses to high school students an appropriate idea?
2. Will the widespread use of satellite technology have a positive impact on the teaching profession?
3. Will the school curriculum be effected positively by the use of satellite technology?
4. Are adequate controls included when satellite courses are planned and delivered, in order to maintain quality of content?

RESULTS OF STUDY #1: Superintendent's Survey

Background

This study surveyed all of Iowa's school superintendents to query them about their receptiveness to the use of satellite technology for the delivery of junior and senior high school courses. A survey form was developed and mailed to 436 Iowa superintendents. Two hundred sixty-one (261) were returned. A second mailing was sent to the 175 who had not responded. Sixty-seven responded to the second mailing. The return totaled 328 (75.2%). Responses from all areas of the state were received.

Those who responded

The average daily attendance of the schools who responded was 900. Two hundred thirty-three (233) of those responding indicated that their enrollments were declining, and 37 indicated rising enrollment trends. Seventh through eighth grade was the most prevalent junior high school organization (147 of those responding, 44%), and 9-12th grades was the most common high school organizational pattern (261 of those responding, 77%).

Ninety-one (27%) of the superintendents who responded said that their schools were in communities of less than 1,000 population. Two hundred ten (210) superintendents (62%) indicated their communities ranged between 1,000 and 10,000. Twenty-five schools (7%) from which superintendents responded were from cities larger than 50,000.

Study #1 - Part #1: Status of Satellite Use

Twenty (5.9%) superintendents indicated their schools currently owned satellite reception systems. Seventy-eight (23%) stated they had plans to install systems in the immediate future.

Twelve superintendents said they were subscribers to TI-IN, the commercial satellite course delivery network. Thirty-one superintendents indicated that they were definitely considering subscribing to TI-IN. Twenty-one said they were interested in subscribing, and eighty-seven said they were unsure. One hundred twenty-seven (127) were definitely not interested in TI-IN. Responses to this question were correlated to the perceived benefits superintendents felt could be derived from using satellites to deliver courses (r=.43) and to the question about the appropriateness of the use of satellites to deliver courses (r=.39). In other words, those superintendents who where considering subscribing to TI-IN were likely to be positive about the benefits of this kind of course delivery. Certainly, this was to be expected. What was somewhat unexpected was that the superintendents who felt this way did not tend to be from any particular size of community (small or large).

Study #1 - Part #2: Attitudes held by Superintendents about Satellite Technology

Knowledge About Satellite Technology

In general, superintendents considered themselves not to be very knowledgeable about satellite technology. Only ten felt they "knew a great deal, " and only 65 felt they "knew quite a bit". One hundred thirty-five (135) said they knew a little. The correlation between answers to this question and the question that asked about knowledge of TI-IN was a highly significant one (r=.60), indicating that those superintendents who knew about satellites also knew about TI-IN and vice-versa.

Superintendents said they learned about satellite technology from reading (N=78), in-service sessions (N=135), and vendors (N=24). Forty-eight percent of the superintendents considered that they were the most knowledgeable person in their school concerning satellites. Other knowledgeable persons were principals (12%) and media specialists (11%). Nineteen percent of the superintendents said no one in their school was knowledgeable about satellites.

Perceptions About Satellite Delivery of Courses

One hundred eighty-one of the superintendents (54%) reported that they saw value in the use of satellite technology to deliver courses for credit. Two hundred eighteen (65%) said they would allow students in their schools to take courses delivered by satellite.

Superintendents seemed most positive about the use of home state teachers as part of a statewide system of satellite course delivery. One hundred and ninety said they would consider subscribing to such a system (56%). Only twenty (6%) were opposed to subscribing. Responses to this question were significantly correlated to answers to questions asking about perceived benefits of using satellites (r=.61) and about acceptance of the idea of using satellites (r=.57).

When asked about who should teach satellite courses, local state certified teachers were rated highest (82% positive), out-of-state certified teachers were rated second (54%), professors rated third (50% positive), and certified graduate students were rated least positively (44%).

One important question in this section of the survey asked "do you think courses for junior and senior high school students should be taught using satellite delivery systems?" It was answered positively by 218 superintendents (65%). Only fifty-two superintendents (15.4%) indicated that they were strongly or somewhat opposed to the use of satellites to deliver courses.

Teacher and Teacher Organization Reactions to Satellites

Superintendents felt that their teachers would positively react to the use of satellite delivery systems (156 yes; 57 no). They were also asked to assess the local teacher organization's reactions to the use of satellites. Superintendents felt that teacher organizations would react:

Very Negatively = 8
Negatively = 70
Neutrally = 64
Positively = 85
Very Positively = 5

Study #1 - Part #3: Immediate Plans for Use of Satellite Technology

As was stated earlier, twenty superintendents reported that their schools owned satellite reception systems, and 78 said they planned to purchase satellite receivers in the near future. Several superintendents (twelve) stated that they planned to purchase more than one system.

The RF frequencies received by those systems already installed were split about in thirds. One-third were C-band, one-third were Ku-band and one-third of the systems were capable of receiving both bands.

Thirty-one superintendents said "yes" they were contemplating subscribing to TI-IN (answered 5 on a 5-point scale). The total number of positive responses to this question was 139 (42%).

A related question asked the superintendents if they would consider subscribing to a satellite system if it originated in their home state. One hundred ninety (58%) said they would consider subscribing (43=definitely yes; 147=yes), and 123 were unsure. Only one superintendent chose the definitely not option.

Table 1. Attitudes of Students Towards Satellite Instruction

Subtest	Number responding	Range of scores	Mean score *	SD	Highest possible score	Reliability of subtest
Strengths of satellite instruction	290	7-49	31.64 (2.88)	7.06 (.64)	55	.76
Adequacy of interaction level	290	3-40	25.75 (3.22)	5.33 (.67)	40	.72
Benefits beyond content of satellite courses	290	2-25	13.69 (2.74)	4.21 (.84)	25	.79
Satellite courses not too difficult	290	9-42	24.83 (2.76)	5.82 (.65)	45	.75
Support for use of satellite instruction	290	8-34	21.47 (3.07)	5.48 (.78)	35	.72

* Higher scores = more positive attitude.
All statements were answered using a 5-point Likert Scale.

Number of Students in One Class

One hundred five (105) superintendents felt that one satellite teacher should have less than thirty students. Thirty-two felt a satellite teacher could handle up to forty students. Twenty-six thought fifty should be the enrollment cap, and only fourteen would want one satellite teacher to have as many as sixty students.

Grading

Superintendents were asked how they would want their students to be graded in a satellite course. Their responses were:

117 wanted an end of course grade only (A-F)
2 wanted an end of course percentile rank in class
6 wanted an anecdotal report
15 wanted grade and rank in class
18 wanted grade and anecdotal report
63 wanted grade, rank, and report

Other Satellite Offerings

One hundred sixty-seven (167) superintendents reported that they would like to see non-credit, enrichment courses offered by satellites. They were also very positive about using satellite technology to deliver graduate level courses for their teachers ($\bar{x}$=3.89, SD=.99; scale ranged from 1=definitely no, do not offer; 5=definitely yes, offer).

Funding

One hundred fifty-eight (158) of the superintendents felt that satellite courses, if offered, should be partially or totally funded by a state agency. Forty-one indicated that these courses should be funded by local districts.

Superintendents were asked how much their districts would pay to enroll one student for one semester:

108 would pay less than $200/student
89 would pay $200-400/student
9 would pay $400-600/student
2 would pay $600-800/student
2 would pay $800-1000/student

Study #1: Conclusions

A significantly large number of Iowa school superintendents were positive about the use of satellite technology to deliver courses for credit. While the superintendents who responded to this survey were far from unanimous in this positive attitude, it did not seem that any clearly identifiable subset of administrators wanted satellites to be used more or less than any other category. Positive (and to a less extent, negative) opinions seemed to proportionally distributed among the superintendents without correlation to school size, community size, or community location. While superintendents in general reported that they knew relatively little about satellite technology, there was a significant relationship between level of understanding and positive attitudes. While it was likely that those superintendents who knew the most were ones who either had already subscribed to, or were seriously considering subscribing to, the TI-IN network, it also seemed that these superintendents had these positive opinions because they felt satellites were a good idea and not as a way to rationalize their decisions.

According to the superintendents, characteristics of a satellite system should probably be as follows:

- offer foreign language, science and math
- offer semester-long (18 week) courses lasting forty-five minutes per day, probably during school hours in the afternoon
- cost less than $400 per student
- grade students with traditional letter grades (A-F) supported by anecdotal reports
- offer some enrichment programming
- offer after-school graduate-level professional courses for teachers

RESULTS OF STUDY #2: Student Survey

The purpose of this study was to describe the attitudes of high school students toward interactive satellite instruction; to identify, through student opinion, the unique qualities of interactive satellite instruction; and to suggest recommendations for improvement.

A two-part questionnaire, called the Study of Satellite Instruction (SSI) was designed to provide answers to the study's research questions. The purpose of Part One of the SSI was to obtain background information in order to establish a profile of characteristics of high school students enrolled in TI-IN courses and describe why students had enrolled in TI-IN course. The purpose of Part Two of the SSI was to describe the attitudes of high school students toward interactive satellite instruction and provide an opportunity for them to suggest recommendations for improvement of satellite courses.

A list of the names of TI-IN subscribers in six states was compiled from viewing TI-IN classes. Twenty-four school districts were randomly selected from this list and administrators were contacted by phone. Twenty-three school districts returned their student's surveys. The school district return rate was 96%. The return rate of students was 73%.

Part One of the SSI identified background information about the TI-IN students and their schools.

The students surveyed were characterized as follows:

- 57% were female and 43% were male.
- 31% were seniors, 28% were juniors, 27% were sophomores, 12% were freshmen, and 2% were 8th graders.
- 39% of the students considered themselves to be A students and 49% considered themselves B students
- 74% of the students thought they would receive a B or better in the TI-IN course they were taking.
- 95% were taking their first TI-IN course.
- 83% were enrolled in a foreign language course.

Additionally, students reported that:

- their high school was small ($\overline{x}$=149 students).
- their TI-IN class had 8 students enrolled, locally. (Range=1-21).
- they estimated their TI-IN class enrolled over 100 students, nationally.

Part Two of the questionnaire consisted of 40 statements that were answered using a Likert-like agreement scale. Each of the statements was placed into one of five individual subtests measuring a different attitude construct. Each attitude subtest related to a research question. A reliability coefficient of above .70 was reported for all subtests (See Table 1).

The results of responses from 290 students showed that on the whole students had positive attitudes toward satellite instruction. The students held positive attitudes toward satellite instruction ($\overline{x}$ = 2.88) and felt TI-IN teachers were a major strength. Specifically, students were positive ($\overline{x}$ = 3.22) in their attitude toward the level of interaction between student and instructor, yet mixed responses indicated that students would have liked more opportunities for communication. The results showed that students had only a slightly positive attitude ($\overline{x}$ = 2.74) toward the benefits of satellite instruction beyond course content. Students did not perceive the establishment of relationships with other students and the development of independent learning as major benefits of TI-IN. The data showed that students did not feel satellite courses were overly difficult ($\overline{x}$ = 2.76). Students favorably supported the use of satellite instruction ($\overline{x}$ = 3.07), even though they tended to prefer traditional courses over satellite courses.

The relationships and differences between variables were analyzed next (see Table 2). The number of students in the local class correlated positively with all attitude subtest scores, indicating that students tended to want the traditional "live" contact with other students, even though they had many TV classmates. The data indicated that students who took classes in the morning had a more positive attitude toward interactive satellite instruction than students who were taking classes in the afternoon.

Table 2. Correlation matrix: Degree of Relationship Between Characteristics of Students and Score of Subtests of Attitude Toward Satellite Instruction.

	A	B	C	D	E	F	G	H	I
A. Ability of student	1.00	.50*	.04	-.06	.13	.04	.11	.12	.15*
B. Grade expected		1.00	.15	.04	.29*	.07	.26*	.37*	.35*
C. Local number in class			1.00	.14	.36*	.22*	.46*	.14*	.44*
D. Total number in class				1.00	.04	-.06	.10	.09	.05
E. Strengths of satellite instruction					1.00	.55*	.66*	.47*	.76*
F. Adequacy of interaction level						1.00	.30*	.25*	.41*
G. Benefits beyond satellite course content							1.00	.38*	.74*
H. Satellite courses not too difficult								1.00	.53*
I. Support for use of Satellite instruction									1.00

The most frequent response given by the students about what influenced them to take a satellite course was "interest in the subject", yet the students who gave this reason for enrolling in a satellite course generally tended to have a low positive attitude toward interactive satellite instruction. Other factors besides their interest in the subject may have strongly affected their attitude once the course was in progress. Students who named the principal or superintendent as the major influence for why they took a satellite course showed a more positive attitude than the students who named other influences. Support by the administration seemed to be a major factor in the success of an interactive satellite program.

A list of what students liked best and least about their satellite course and a list of suggestions for improvement of interactive satellite instruction was complied from three open-ended questions (Tables #3, #4, and #5). Although generally students had positive attitudes toward instruction via satellite, the development of more interesting methods to present course material and the reduction of total class size in order to provide more student-teacher interaction and remedy the congested phone system were recommendations made to improve interactive satellite instruction.

RESULTS OF STUDY #3: Teacher and Administrator Leader Survey

The responses from the questionnaire, Opinions of Teacher Leaders and School Administrators Toward Satellite Delivery of Instruction (OTLSA), were used to describe the attitudes of these individuals toward satellite delivery of courses for high school credit. The data were collected from the OTLSA and statistically analyzed.

This section of this paper contains the results of the statistical procedures used to: (1) provide a descriptive profile of the participating respondents, (2) present a brief description of the respondent's school district, (3) provide a summary of the attitudes of respondents toward interactive satellite instruction, (4) provide an examination of relevant relationships among variables used in the study, and (5) present a summary of potential problems foreseen and additional comments about the use of satellite courses.

The rate of return for the OTLSA was good. The return rate of the teacher leaders' and school administrators' questionnaires was calculated using 100 as the number of individuals sampled and 80 as the number of returned questionnaires, so the overall return rate was eighty percent. Teacher leaders returned 36 surveys for a return rate of seventy-two percent, and the school administrators returned 44 surveys for a return rate of eighty-eight percent.

Profile of Respondents

The purpose of Part One of the OTLSA was to proved a descriptive profile of the sample. Frequency distributions were computed for each item in Part One of the OTLSA in order to describe characteristics of the sample.

The characteristics of the sample are described and reported in the same order that the question relating to that characteristic appeared in Part One of the OTLSA:

Table 3. What Students Liked Best About Their Satellite Course

Response	Number of responses
Subject was interesting	64
Good teacher; good personality	37
Easier than traditional	34
Meet and talk to other students	33
Nothing	28
Different; change in routine	22
Relaxed, fun	20
Teacher not present	17
Opportunity to take course not offered; needed for college	17
Interesting specials	12
Challenging; learning more	11
Fosters independent learning	11
Chance to call in	9
Everything	5
Total	320

Table 4. What Students Liked Least About Their Satellite Course

Response	Number of responses
Boring; uninteresting	53
Hard to understand	35
Too much homework and labs	35
Calling is difficult	27
Instructor unorganized and hard to understand	26
Lack of communication	21
Scheduled at a poor time of day	20
Tests too difficult	14
Unable to ask questions; feel uncomfortable	11
Everything	10
Hard to make up work from vacations or absences	9
OK the way it is	9
Poor TV reception	8
Not challenging	6
Impersonal and not enough interaction with other students	5
Poor phone connections	4
Subject matter	3
Total	296

Table 5. Student Suggestions for Improvement of Satellite Courses

Response	Number of responses
More variety	33
More student-teacher interaction	30
More organization	25
Improve phone system	18
Reduce class size	17
More involvement with other students	14
Schedule at a different time	14
Better TV reception	13
More courses and different course levels	12
Eliminate satellite courses	12
Improve tests and grading methods	8
Facilitators receive more training	7
More handouts and study guides	5
Total	208

(1) Overall, sixty-four percent (63.75%) of the respondents were male, and approximately thirty-six percent (36.25%) of the respondents were female. Teacher leaders were sixty-one percent (61.11%) female and thirty-nine percent (38.89%) male. School administrators who returned to OTLSA were eighty-four percent (84.09%) male and sixteen percent (15.91%) female.

(2) Overall, the average age of the respondents was found to be 47.31 years. teacher leaders' average age was 43.53 years. Females and males averaged 44.05 and 452.71 years of age, respectively. School administrators' averaged 50.41 years of age. Female administrators averaged 44.57 years, and males averaged 51.51 years of age.

(3) All of the respondents were asked to indicate the highest academic degree they had successfully completed, or credits they had toward the next highest degree. All had credits beyond an undergraduate college degree. Approximately twenty-six percent (26.25%) had received a Doctorate and thirty-three percent (32.50%) had credits towards a Doctorate. Thirty-four percent (33.75%) of all the respondents had received a master's degree and eight percent (7.50%) had credits toward a master's degree. Approximately six percent (5.56%) of teacher leaders had a Doctorate and twenty-two percent (22.22%) had credits towards a Doctorate. Fifty-six percent (55.56%) of teacher leaders had received a master's degree and seventeen percent (16.67%) had credits toward a master's degree. Forty-three percent (43.18%) had received a Doctorate, forty-one percent (40.91%) had credits toward a Doctorate, and sixteen percent (15.91%) had a master's degree.

(4) Overall the average number of years employed in education for the entire group of those responding (combination of years as teacher and/or administrator) was 23.50 years. Teacher leaders averaged 20.03 years in education. Females averaged 19.05 years and males averaged 21.57 years of experience. School administrator leaders averaged 20.43 and 27.46 years, respectively.

Description of Respondents' School Districts

Each respondent was asked to answer questions concerning the school district where they were currently or most recently employed. The school districts were located across the United States. Questions about the school district's enrollment size, recent fluctuations in enrollment, and use of satellite reception systems were asked, also.

(1) As expected, the size of the school districts varied. The percentages of each category were:

Less than 1,000 - 9%
1,000-5,000 - 38%
5,000-15,000 - 38%
15,000-25,000 - 9%
25,000-45,000 - 6%
over 45,000 - 6%

(2) Forty percent of the respondents indicated that their school district had recently increased in enrollment. Thirty-six (36.25%) said that their school district had stayed about the same size, and twenty-four percent (23.75%) said their districts had decreased in enrollment.

(3) The majority (83.75%) of the respondents indicated that their school district was doing little with satellite delivery systems. Nine percent (8.75%) were considering implementing a satellite reception system for courses, and eight percent (7.50%) were currently using a satellite reception system for courses.

Attitudes of Teacher Leaders and School Administrators

The primary purpose of this study was to describe the attitudes of teacher leaders and school administrators toward delivery of interactive satellite instruction. The teacher leaders and school administrators were asked to choose the response that best described how they felt about each of the 30 statements in Part II of the OTLSA. The respondents used the following Likert-like scale:

SA = Strongly Agree
A = Agree
U = Undecided
D = Disagree
SD = Strongly Disagree

In order to answer the research questions, each of the 30 statements in Part II of the OTLSA was placed into one of four attitude categories or subtests. Each subtest was relevant to one of the research questions. Each subtest was considered an individual measure of an attitude construct and was examined separately.

The reliability of each subtest was computed. A reliability coefficient of above .70 was reported for all but one subtest.

An indication of favorable positive attitude, or an unfavorable negative attitude was determined by the following statistical procedures:

(1) The mean for each subtest was computed. A score at or above the midpoint of total possible points was considered a favorable attitude. A score below this midpoint was considered an unfavorable attitude.

(2) The average score (mean) was found for each item to allow the researcher to examine each subtest item separately. A score of 2.50 or above was considered to indicate a favorable attitude for each item. A score of less than 2.50 was considered a negative attitude (Table 7).

Satellite instruction is considered appropriate

Subtest: What is the appropriateness of using satellites to deliver courses for credit to high school students (Appropriateness of Satellite Instruction)?

Table 7 indicates that teacher leaders and school administrators hold a generally neutral but positive attitude ($\overline{x}$=24.35) toward the appropriateness of satellite instruction. The subtest, Appropriateness of Satellite Instruction, had a possible total score of 40. A score of 21 or above indicated a positive attitude. An analysis of the subtest's items showed that teacher leaders and school administrators generally did not consider satellite delivery of instruction the same as TV courses ($\overline{x}$=3.69), and that satellite courses probably would motivate and hold the interest of students ($\overline{x}$=3.16).

Satellite instruction has positive effects on the teaching profession

Subtest: What is the effect on the teaching profession if satellite course delivery becomes widespread (Effect on Teaching Profession)?

The average of the subtest, Effect on Teaching Profession ($\overline{x}$=25.25), indicated that teacher leaders and school administrators generally held a positive attitude toward the effect that satellite instruction had, or would have, on the teaching profession. The highest possible score was 35. A positive score was 18 or above. An analysis of the subtests' items indicated that teacher leaders and school administrators believed that teachers' job opportunities would probably not be reduced because of satellite delivery of instruction ($\overline{x}$=3.68).

Table 6. Study 3 - Description of Those Responding

Gender	Teacher Leaders	Administrative Leaders	Totals
Female	61% (22)	16% (7)	36% (29)
Male	39% (15)	84% (37)	64% (51)

Approximate Age	Teacher Leaders	Adminstrative Leaders	Averages
	43	50	47

Formal Education	Teacher Leaders	Administrative Leaders
Doctorate	6%	43%
Masters +	22%	41%
Masters	56%	16%
Bachelor +	16%	

Years of Experience	Teacher Leaders	Administrative Leaders	Average
	20	26	23.5

School Size	Less than 1000	1000-5000	5000-15000	15000-25000	25000-45000	more than 45000
	9%	35%	35%	9%	6%	6%

Table 7. Attitudes toward satellite instruction: subtest scores

Subtest	Number Responding	Range of Scores	Mean Score*	SD	Highest Possible Score	Reliability of Subtest
Appropriateness of Satellite Instruction	80	13-31	24.35 (3.04)	3.92 (.49)	40	.75
Effect on the Teaching Profession	80	15-33	25.25 (3.61)	3.72 (.53)	35	.72
Effect on the School Curriculum	80	15-32	22.95 (3.28)	3.46 (.49)	35	.72
Perceptions of Needed Controls	80	16-35	24.95 (3.12)	3.59 (.45)	40	.64

*Higher scores = more positive attitude.

Satellite instruction has a positive effect on the school curriculum

Subtest: What will be the effect on the school curriculum in order to accommodate satellite courses (Effect on the School Curriculum)?

Table 8 shows the subtest, Effect on the School Curriculum, had a possible total score of 35. A favorable attitude score was 18 or above. The average score was found to be 22.95 and indicated that teacher leaders and school administrators had a generally positive opinion toward the effect that satellite instruction would have on the school curriculum.

Satellite instruction has the needed controls

Subtest: What are the teacher leaders' and school administrators' perceptions of the controls that will be needed when satellite courses are planned and delivered in order to maintain quality of content (Perceptions of Needed Controls)?

The mean of the subtest, perceptions of needed controls ($\bar{x}$=24.95), indicated that teacher leaders and school administrators favored the controls currently in place for satellite instruction. The subtest had a possible score of 40. A positive score was 21 or more. An item analysis of the teacher leaders' and school administrators' subtest responses showed that they felt satellite course instructors should be certified in the receiving state ($\bar{x}$=3.55).

Additional Analysis

Descriptive statistics of all student characteristics and subtest scores were examined to determine if further analyses were appropriate. The data were analyzed using Pearson product moment correlation and t-tests.

Correlation

The Pearson product moment correlation technique was used to determine the strength of the relationship between the characteristics of teacher leaders and school administrators and the subtests. The characteristics examines were (1) sex of respondent, (2) the highest degree received, or credits towards one (degree), (3) the number of years the respondents had been employed in education, (4) the respondents' school district's enrollment for K-12, (5) their district's enrollment fluctuations, and (6) their district's current usage of satellite reception systems (current satellite usage).

The most interesting observation derived from the analysis of the correlations was that while there were a number of statistically significant correlations, there were few practically significant relationships.

Table 8. Correlation matrix: Degree of relationship between characteristics of Study #3 sample and attitude subtest scores.

	Sex of Respondent	Highest Degree Received	Years Employed in Education	School District's Enrollment
Sex of respondent		.27	.44	.43
Highest degree			.33	-.13
Years employed in education				-.29
School district's enrollment				
Enrollment fluctuations				
School district's current satellite usage				
Appropriateness of satellite instruction				
Effect on the teaching profession				
Effect on the school curriculum				
Perceptions of needed controls				

Table 8. Correlation matrix - continued.

	Enrollment Fluctuations	School District's Current Satellite Usage	Appropriateness of Satellite Instruction	Effect on the Teaching Profession
Sex of respondent	.14	-.01	.28	-.09
Highest degree	-.13	-.10	.27	-.19
Years employed in education	-.29	-.16	.44	-.01
School district's enrollment	.34	-.02	-.02	.24
Enrollment fluctuations		.03	-.07	-.04
School district's current satellite usage			-.22	.03
Appropriateness of satellite instruction				.12
Effect on the teaching profession				
Effect on the school curriculum				
Perceptions of needed controls				

Table 8. Correlations matrix - continued.

	Effect on the School Curriculum	Perceptions of Needed Controls
Sex of respondent	.20	.20
Highest degree	.19	.17
Years employed in education	.14	-.21
School district's enrollment	.30	.48
Enrollment fluctuations	-.25	.11
School district's current satellite usage	-.15	-.01
Appropriateness of satellite instruction	.38	.63
Effect on the teaching profession	.35	.24
Effect on the school curriculum		.24
Perceptions of needed controls		

t-tests

The t-test was used to determine if there was a significant difference between teacher leader's and school administrator's subtest scores. Table 9 shows that the average scores of teacher leaders and school administrators for the subtest, Effect on the Teaching Profession, were almost identical. All other subtest scores were quite different. The level of significance (p) for two subtests, Appropriateness of Satellite Instruction ($p < .0001$) and Perceptions of Need Controls subtest results ($p < .01$), showed that there was a highly significant difference between the attitudes of teachers and administrators. In other words, administrator leaders tended to have more positive attitudes than teacher leaders about the use of satellite technology. Also, administrators seemed to be less in favor of more controls on the use of satellite technology in the schools than were teachers.

The t-test was also used to determine if there was a significant difference between males' and females' subtest scores. The t-test indicted that males had more favorable attitude scores on all but one subtest (Perceptions of Needed Controls) than females (Table 4). In other words, males generally tended to be more positive than females about the use of satellite technology, and males tended to be less in favor of more controls than females.

Suggested Improvements

A second purpose of this study was to identify, by using teacher leaders' and school administrators' opinions, potential problems that might occur with the routine use of satellite courses. This information was obtained in Part Two of the OTLSA.

These questions were stated in an open-ended format so that respondents could express their opinions and give unprompted responses. Similar responses were grouped. The responses were ranked from the most frequent response to the least frequent response.

The first question asked the respondents to describe what potential problems they anticipated if school districts began to routinely use satellite courses for credit. The most frequent responses in descending order were:

(1) Satellite courses would not provide for the individualization of teaching or learning (n=13).
(2) There would be a problem in scheduling (n=9).
(3) Local curriculum vs. a standardized curriculum might be a problem (n=9).
(4) Teacher employment opportunities would be reduced (n=8).
(5) Certification of satellite teacher and local monitor was a concern (n=7).
(6) The cost of the initial installation would be high (n=5).
(7) Satellite courses would not be motivating to students (n=5).

Table 9. t-tests - Attitudes Toward Satellite Instruction: Teachers vs. Administrators

Subtest	N	x	SD	t-value	p
Appropriateness of Satellite Instruction:					
Teacher Leaders	36	22.14	4.21	-4.39	.01
		(2.77)	(.53)		
School Administrators	44	26.16	2.52		
		(3.27)	(.32)		
Effect on the Teaching Profession:					
Teacher Leaders	36	25.44	3.44	.23	.82
		(3.63)	(.49)		
School Administrators	44	25.09	3.98		
		(3.58)	(.56)		
Effect on the School Curriculum:					
Teacher Leaders	36	21.97	3.94	-1.85	.07
		(3.14)	(.56)		
School Administrators	44	23.75	2.81		
		(3.39)	(.40)		
Perceptions of Needed Controls:					
Teacher Leaders	36	26.50	3.54	2.80	.01*
		(3.31)	(.44)		
School Administrators	44	23.68	3.12		
		(2.96)	(.39)		

*Higher scores = more positive attitudes.

Table 10. Potential problems.

Responses	Number of Responses
Lack of individualization	13
Scheduling	9
Local curriculum vs. standardized curriculum	9
Teacher jobs reduced	8
Certification of satellite teacher and monitor	7
Cost	5
Lack of motivation for students	5
Teacher union opposition	3
Quality of satellite instruction	3
Commitment for all involved	1
Total	63

The second question asked the teacher leaders and school administrators to give additional comments about the use of satellites to deliver courses for credit (see Table 11). Their responses, in descending order of frequency, were:

(1) Satellite instruction is a plus for small and rural schools (n=8).
(2) Satellite delivery of courses offers many curriculum enhancement opportunities (n=7).
(3) Quality of the satellite course is important. Teacher leaders and school administrators felt that the courses needed to provide immediate feedback and the satellite teacher needed to be very knowledgeable (n=5).
(4) The monitor's (teacher in the downlink school) role must be clarified (n=3).

Conclusions

It was hoped that the results of these three studies would yield a somewhat comprehensive picture of the perceptions of administrators, teachers, and students toward satellite technology. While it is certainly difficult to arrive at conclusions from survey research, there are trends and implications that seem obvious when the results of each study are evaluated.

- Superintendents were generally in favor of the use of satellite technology to deliver courses for credit, and many had plans to install satellite reception systems in their school districts.

- Students who were currently enrolled in a course being delivered by satellite technology were generally positive about the experience. Students tended to be more positive if they had a number of local classmates taking their course with them.

- Students suggested that more variety was needed to make satellite delivered courses more interesting.

- Generally, leaders of state teacher and administrator associations were positive about the use of satellite technology, although administrator leaders tended to be more positive than teachers and tended to expect fewer controls on those using this technology.

Most notable was the generally reported positive attitude toward the use of this new technology in a distance education situation. Certainly, satellite technology is not opening to "rave reviews." Just as certainly, it is a technology with considerable potential that at worst invokes a "wait-and-see" attitude. At best, satellite technology is being positively, if somewhat cautiously, endorsed.

Table 11. Additional comments.

Response	Number of Responses
Satellite instruction is a strength in small and rural schools	8
Satellite delivery of courses offers many enhancement opportunities	4
Enrichment courses	2
Instruction should provide feedback	2
Quality of satellite course	2
Clarification of monitor's role	2
Advanced level courses	1
Satellite teacher needs to be knowledgeable	1
Monitor needs to be a teacher	1
Total	33

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Title:

The Best Colors for Audio-Visual Materials for More Effective Instruction

Author:

Dr. Jay Start

TITLE: THE BEST COLORS FOR AUDIO-VISUAL MATERIALS FOR MORE EFFECTIVE INSTRUCTION.

AUTHOR: Dr. Jay Start, Indiana University of Pennsylvania

RATIONALE:

The use of instructional materials in education has been given universal acceptance as, not only an aid, but in some instances, a primary force in the educational process. However, when designing materials there are many variables that can have an effect on the intended audiences ability to percieve and in turn learn from the materials. Variables such as time, color, and the interaction of time and color have been shown by previous research to play an important role in the learning process. Metcalf (1968) studied the effect on visual acuity of black and white slides and viewer angle. Costello (1969) studied captions and readability of slides. Snowberg (1972) studied subjects visual acuity of slides with colored backgrounds and white symbols.

Since Metcalf (1968) examined black backgrounds and white symbols, and Costello (1969) sought to determine the most readable captions, and finally Snowberg (1972) studied black symbols on colored backgrounds, the question arises about the effect of black backgrounds and colored symbols. What happens to visual acuity when colored symbols are used? And what role does time play on visual acuity? The present study was undertaken to examine these questions.

The purpose of this study was twofold: 1. Determine what projected color provides the best visual acuity for the viewer. 2. Determine the minimum exposure time necessary for maximum visual acuity.

To answer these questions the following research questions were investigated:

1. When illumination, distance and reflectance remain constant, do various colors differentially facilitate the recognition of Landolt Ring placement?

2. Does an interaction exist between stimulus exposure time and the degree to which various colors facilitate recognition of Landolt Ring placement?

METHODOLOGY

The methodology of this study can be described in five categories: selection of the population, instrumentation, stimulus materials, experimental procedures, and, research design.

1. Selection of the population

The population for this study consisted of 50 undergraduate students, all of whom were be between the ages of 18-22. All subjects were enrolled in the Communication program at Duquesne University, Pittsburgh, Pennsylvania. Participation in this study was on a volunteer basis. Students were urged to participate but also assured that their grade would not suffer or improve because of non-participation or participation.

All subjects were given eye examinations for both visual acuity and color deficiency. Those individuals failing the eye examinations for color deficiency and/or visual acuity were illiminated from the test population.

2. Instrumentation

All testing took place in two rooms. One room was used for testing visual acuity and color visual deficiencies. The other room was used for the presentation of the stimulus. The available light in this room was between 10 and 15 Foot Lumens at all times during testing.

Stimulus materials were projected using a Kodak Ektagraphic Model B-2 Carrousel slide projector with a Kodak f 3.5 projection Ektanar zoom lens. The light source was a General Electric 300 watt quartzline lamp ELH 120 volts with a color temperature of 3,375 degrees Kelvin.

Screen reflectance was measured and was the same for each stimulus slide. This was achieved by using neutral density filters.

The time in which the stimulus slides appeared on the screen was controlled by an Ilex Optical Co., Calumet Caltar no. 5 Universal Synchro f 6.3 variable speed lens. The f-stop during testing remained completely open at f 6.3. Both front and rear lens elements were removed so as not to interfere with stimulus projection. Lens speeds were checked by a certified camera technician using an oscilloscope in order to ensure accurate speeds.

3. Stimulus Materials

The colors red (hues 1, 2, 3), blue (hues 1, 2, 3), green (hues 1, 2, 3), and yellow (hues 1, 2, 3) were chosen because they represent the widest portion of the visible spectrum.

To provide three different hues of each color, gels were sandwiched or stacked one upon another as follows;

Roscoe, Lene 821 = Red (1)
Roscoe, Lene 821 + Lene 821 = Red (2)
Roscoe, Lene 821 + Lene 821 + Lene 821 = Red (3)

The above method was also used for Green, Blue, and Yellow.

It was found when previous research was examined that there are two basic tests used when testing visual acuity, Snellen Letters and Landolt Rings. However, when testing color vision Graham (1965) recommends Landolt Rings. When Landolt Rings are used, the observer is asked the location of the gap. The direction of the gap is changed to provide variability.

To determine the proper symbol size the following formula was used:

$$\tan a/2 = s/2d$$

where;

a = visual size
s = size of the object
d = distance of subject from object in the same measurement terms as the size of the object.

(Metcalf, 1969, p.56)

According to Metcalf (1969), after all calculations are completed, the proper symbol gap size is 2 millimeters at 20 feet. Slides were made from paste-ups of the symbols used. The color gels were sandwiched over the symbols. All slides were made using Kodak 35mm high contrast film. Exposure time and development time was the same for each slide to insure uniformity. Slides were mounted in Kodak 2" X 2" plastic slide mounts along with the the colored gels and neutral density filters.

In order to vary the time at which each slide was presented, a variable speed lens with the front and back lens elements removed, was placed in front of the projector lens. The shutter was then opened and the slide focused on the screen. The opacity of the shutter leaves did not permit any light to leave until the shutter was triggered by the operator.

4. Experimental Procedures

A population identification sign up sheet was distributed to students enrolled in Communication courses at Duquesne University. After which subjects were chosen and contacted by the researcher and given an appointment for testing. At which time subjects were asked to read and sign a Human Subjects Consent form before the test was conducted.

After completing a Graham-Field Visual Acuity Test (a standard opthomological test) and an Ishihara Color Vision Test, subjects were seated 20 feet at a 90 degree angle from the screen. The room was darkened, and the following instructions played to the subjects via cassette tape recorder.

> Please look at the screen while I give you the instructions. You will be presented with 208 slides. They will

> either be yellow, blue, green, red, or white. They will be presented at various speeds; although with some, you will be given as much time as you feel is necessary.
>
> After a slide is presented, you will indicate on your answer sheet what direction the break in the circle is, right, left, up, or down. If you cannot tell the direction of the gap, put an X on your answer sheet. After you have decided, tell the operator to continue.
>
> Please stay seated until you are told by the operator that the test is over. Refrain from leaning forward or squinting.
>
> Before we begin, are there any questions?

After the instructions were presented, subjects were given answer sheets.

Subjects were presented with 208 2" X 2" slides. Each series of slides varied in color and symbol gap direction. The speeds in which the slides were presented were 5 seconds, 10 seconds, 15 seconds, and for as long as each subject felt it was necessary. The order in which the slides were presented was determined using a table of random numbers. From which a stimulus presentation order sheet was prepared. It took approximately 30 minutes to complete the test, depending on the length of time it took the subjects to respond.

5. Research Design

This study was a 4 x 13 repeated-measures design. (4 speeds x 13 colors)

The independent variables for this study are color, and exposure time. The dependent variable was each subject's response to the presentation stimulus.

FINDINGS AND CONCLUSIONS

Analysis of the Data

The results of this study were analyzed by means of an Analysis of Variance for repeated measures and are summarized in Table 1.

As can be seen in Table 1, there were three significant effects obtained from the analysis of the data gathered in this research, providing affirmative answers to the two main effects hypothesis and as well to their interaction: Color (F = 136.43; df = 12/588; p < .001), Time (F = 7.28; df = 3/147; p < .001), Color x Time (F = 6.15; df = 36/1764; p < .001).

TABLE 1. ANALYSIS OF VARIANCE SUMMARY TABLE

Source	df	ss	ms	f
Color	12	1980.01385	165.0015	136.43 ***
Error	588	711.14000	1.20942	
Time	3	6.95692	2.31897	7.28 ***
Error	147	46.85077	0.31871	
Color x Time	36	75.46308	2.09620	6.15 ***
Error	1764	601.22923	0.34083	

*** p <.001

Main Effects Statistics.

Table 2 presents the rank order of correct visual acuity test means, with time collapsed across all colors.

TABLE 2. RANK ORDER OF CORRECT VISUAL ACUITY TEST MEANS, WITH TIME COLLAPSED ACROSS ALL COLORS.

Color	Level	Mean
White		3.945500
Yellow	(2)	3.795000
Yellow	(3)	3.760000
Yellow	(1)	3.700000
Blue	(1)	3.680000
Red	(2)	3.655000
Red	(1)	3.650000
Green	(1)	3.590000
Red	(3)	3.505000
Blue	(3)	3.270000
Blue	(2)	3.250000
Green	(2)	2.630000
Green	(3)	0.490000

To better illustrate the results indicated in Table 2, Figure 1 was constructed.

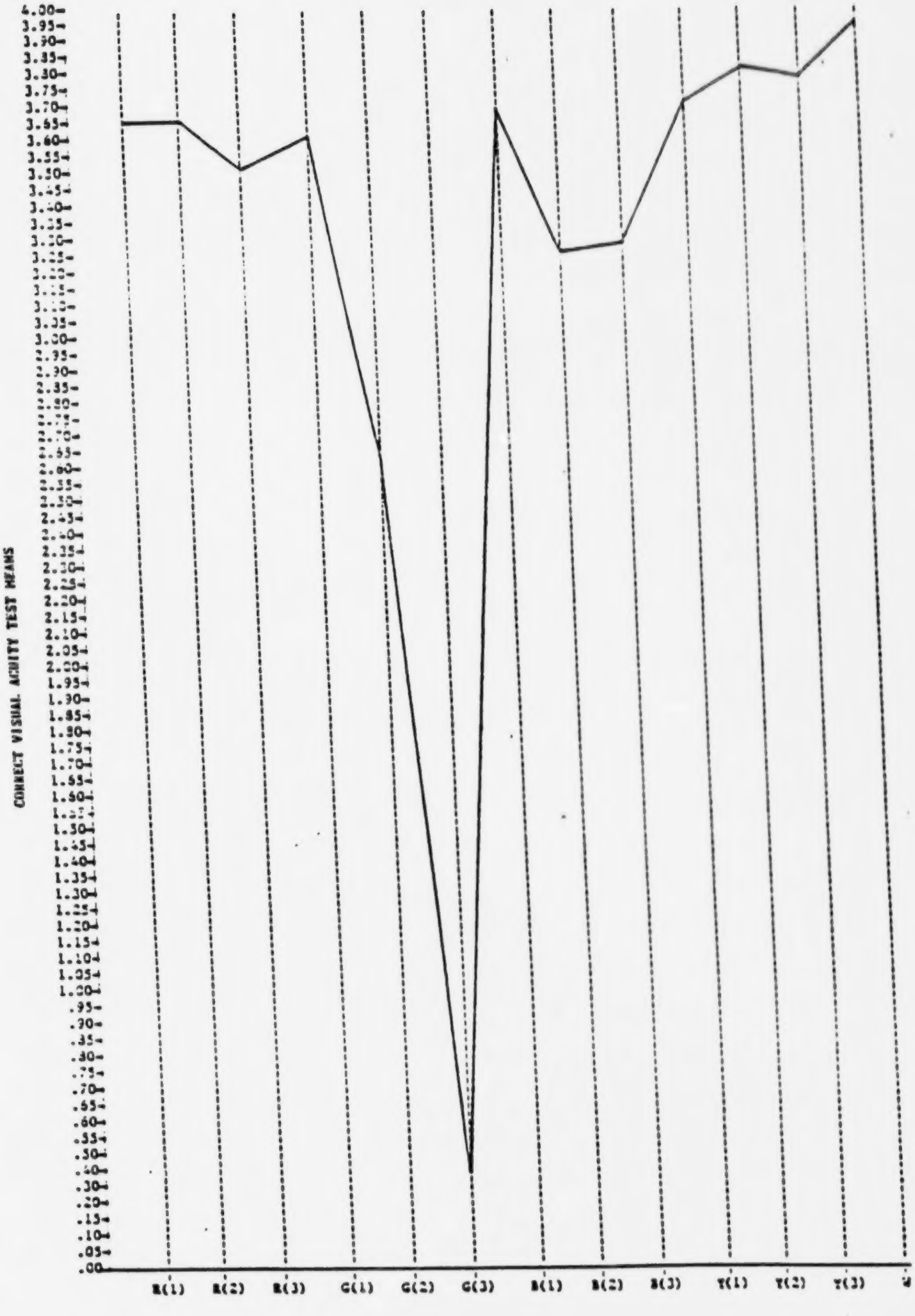


Figure .1 Rank Order of Correct Visual Acuity Test Means, with Time Collapsed Across all Colors.

(Insert figure 1)

As can be seen by examining Table 2 and Figure 1, the color white was seen best followed by yellow level 2 (middle), yellow level 3 (dark), yellow level 1 (light), blue level 1 (light), red level 2 (middle), red level 1 (light), green level 1 (light), red level 3 (dark), blue level 3 (dark), and blue level 2 (middle). The colors providing the poorest mean scores were green level 2 (middle) and green level 3 (dark). The latter provided a rather sharp drop in its visual acuity mean score of 0.490000, a difference of 2.14 from green level 2. The mean difference between white and green level 3 (dark) is 3.4555. Table 3 presents the rank order of correct visual acuity test means, with color collapsed across all times.

TABLE 3. RANK ORDER OF CORRECT VISUAL ACUITY TEST MEANS, WITH COLOR COLLAPSED ACROSS ALL TIMES.

Time	Mean
15 Seconds	3.3180
5 Seconds	3.2900
Unlimited	3.2700
10 Seconds	3.2400

In order to better illustrate the results indicated in Table 3 a graphic respresentation is shown in Figure 2.

(Insert figure 2.)

As can be seen in Table 3 and Figure 2 subjects were better able to see the stimulus (Landolt Rings) at the 15 second presentation time (m = 3.3180), followed by the 5 second time (m = 3.290), when subjects were given as much time as they needed (unlimited) the mean score was 3.270. The poorest stimulus presentation speed was 10 second speed (m = 3.240).

Interaction effects.

In order to show where the interactions of this study's independent variables took place, it was necessary to plot each color across time. These interactions are shown in figure 3.

(Insert figure 3.)

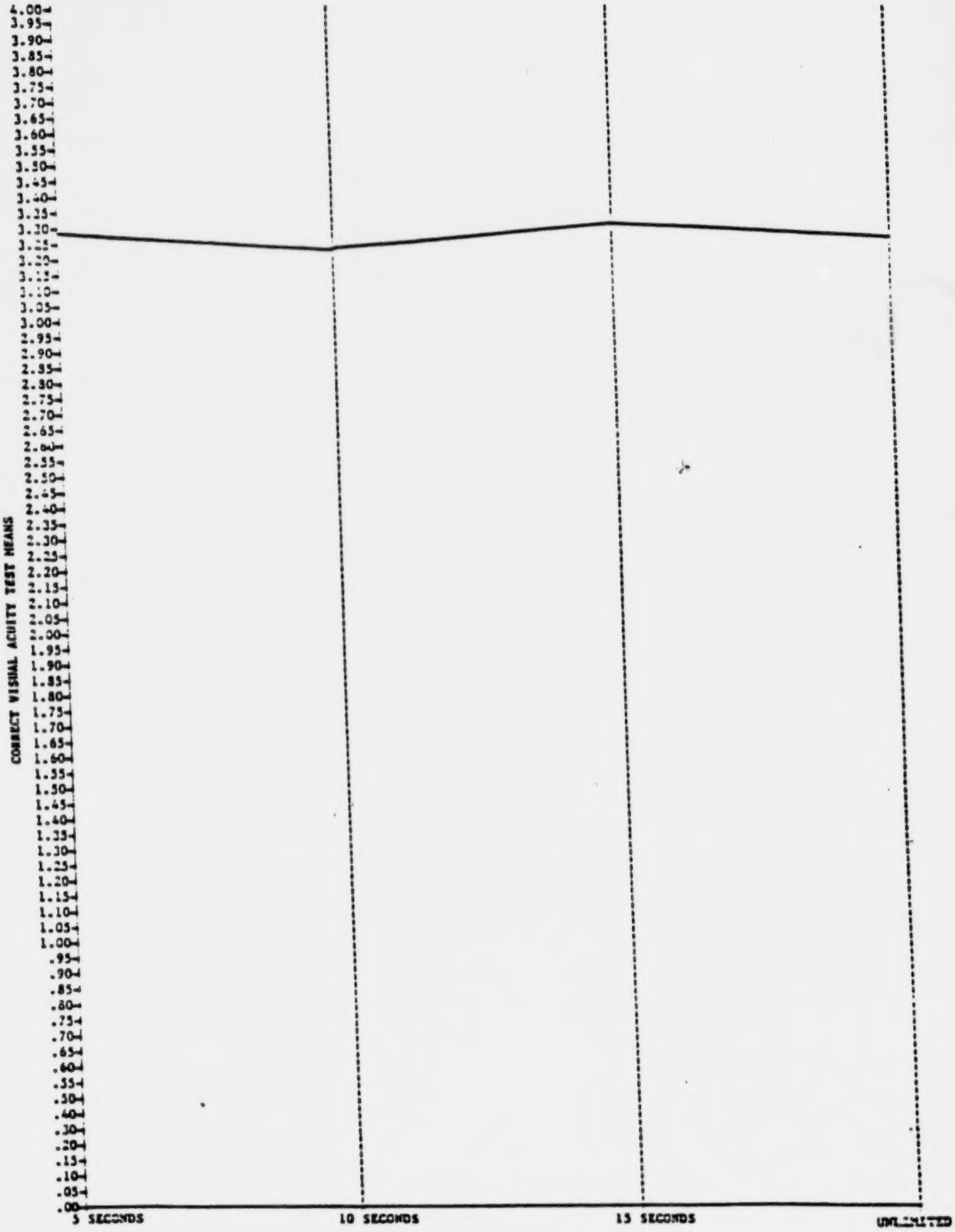
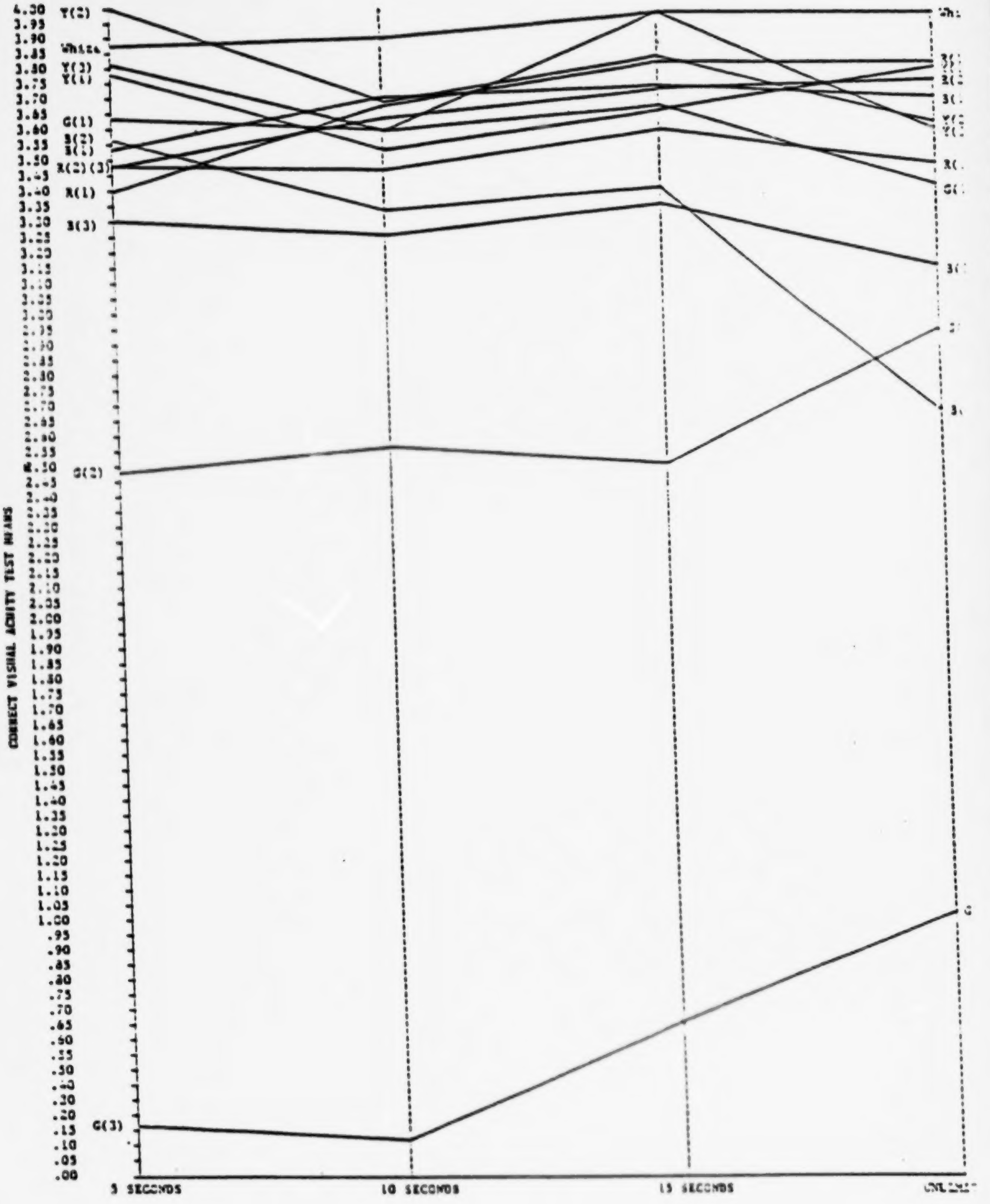


Figure 2. Rank Order of Correct Visual Acuity Test Means, With Color Collapsed Across All Times.



Color and Time Interactions

TABLE 4. HIERARCHIES OF VISUAL ACUITY TEST MEANS BY TIME

5 secs.	10 secs.	15 secs.	unlimited
Yellow (2)	White	White Yel. (3)	White
White	Blue (1)	Yellow (2)	Red (1)
Yellow (3)	Yellow (2)	Red (2) Blue (1)	Yellow (1)
Yellow (1)	Red (1)	Green (1)	Red (2)
Green (1)	Red (2)	Red (1)	Blue (1)
Blue (2)	Yel. (3) Grn. (1)	Yellow (1)	Yellow (2)
Blue (1)	Yellow (1)	Red (3)	Yellow (3)
Red (2 and 3)	Red (3)	Blue (2)	Red (3)
Red (1)	Blue (2)	Blue (3)	Green (1)
Blue (3)	Blue (3)	Green (2)	Blue (3)
Green (2)	Green (2)	Green (3)	Green (2)
Green (3)	Green (3)		Blue (2)
			Green (3)

From the information presented in table 4 and figure 3 the interaction of this study's two independent variables, color and time can be seen and visual acuity tendencies identified. These interactions provide a hierarchy on which specific colors are best at specific times.

After examining where the interactions of this study's independent variables intersect, it can be seen that there are very complex and intricate relationships between the two independent variables. Because of this only those interactions which provided meaningfull differences are discussed.

As can be seen in table 4, subjects were able to see the color white best for three of the four presentation speeds 10 seconds (M = 3.900), 15 seconds (M = 4.00), and unlimited (M = 4.00). At 5 seconds yellow level 2 (medium, M =4.00) was seen best. By far the color providing the poorest visual acuity scores was the color green level 3 (dark) with an overall visual acuity mean at 0.49000 (5 secs = 0.160, 10 secs. = 0.120, 15 secs. = 0.660 and unlimited 1.020). It should be apparent that as overall presentation times increased, so did correct responses. However, there was a drop in correct responses at the 10 second presentation time.

The next poorest color in terms of visual acuity was the color green level 2 (medium), in three of the four presentation times (5 secs. = 2.480, 10 secs. = 2.560, 15 secs. = 2.960). Again, as time increased, so did correct responses. The exception to this was blue level 2 (medium) at unlimited (m = 2.680), giving a disordinal interaction with green level 2.

The next poorest color was blue level 3 (dark) with an overall mean of 3.270 (5 secs. = 3.30, 10 secs. = 3.260, 15 secs. = 3.360, and unlimited = 3.160). It should be noted, however, that when overall mean scores for the various color levels are examined, blue level 3 (dark) did better than blue level 2 (medium). This is do to the disordinal interaction in blue level 2 (medium, m = 2.680) at the unlimited presentation time.

Of those remaining colors, red level 1 (light), red level 2 (medium), red level 3 (dark), green level 1 (light), blue level 1 (light), yellow level 1 (light), and yellow level 3 (dark), there does not appear to be any other meaningful significant interactions.

Summary of findings

From the results presented above it can be concluded that when designing instructional materials the best color to use is the color white, followed by middle yellow, dark yellow, light yellow, light blue, middle red, light green, dark red, dark blue, middle blue, middle green, and dark green. In addition, the longer the amount of time a visual is on screen the more likely it is to be seen. Finally when considering color and time interactions in most instances it can be generalized that as time increases so does a subjects ability to correctly percieve a message regardless of color. It can be further generalized that the best colors to be used in designing projected visuals considering color and time interactions are the colors white, and middle yellow. The poorest colors to use are the colors dark green, middle green, and dark blue.

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Title:

Structure and Organisation in Instructional Text - a cognitive perspective on practice

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Introduction

It has been argued that the content and structure of passages of text are inextricably linked and that students will learn from text better if they can follow the organisation of the material and later use that organisation (Brandt, 1978). It has also been argued that, since comprehension of text can be a cognitively demanding task, authors can help readers to comprehend and recall text information by making sure that the design of their text supports each of the component comprehension processes that the readers must perform, including, *inter alia*, identifying the important ideas in text, organising those ideas, and integrating them with prior knowledge (Glynn & Britton, 1984). The organisation of text can be made explicit through both verbal and typographical cueing systems (Glynn, Britton & Tillman, 1985) but many of the techniques for instructional text design have been developed in either an a-theoretical framework, or a framework which is not very defensible in the light of recent cognitive research.

The purpose of this paper is to consider ways in which the organisation of text can be made explicit through verbal cueing and the ways in which this organisation can be related to the cognitive processes of the reader. In doing so, the paper re-interprets current practice within a cognitive framework.

Highlighting structure and organisation through verbal cues

It has been argued that verbal cueing can be of either a linguistic nature, ie concerned with the semantic and syntactic structure of the text, or of an instructional design nature, ie concerned with verbal support such as advance organizers and adjunct questions which, although an integral part of the text, are not really part of the content (Stewart, 1986).

The concern of this paper is not with the linguistic aspects of text such as structure, coherence, and content, but with those textual factors supplementary to the main content which play an important part in the comprehension of text and are, thus, important elements in the design of text.

In a review of instructional psychology Resnick (1985) acknowledged that the current view of reading comprehension was too recent to have yet generated many instructional applications, but that, *inter alia*, older lines of work on advance organizers, questions, and other adjuncts to text might eventually be reinterpreted in light of the contructivist view of the reading process. For the purpose of this paper, the term 'adjuncts to text' will be taken to include such devices as the statement of behavioural objectives, the provision of advance organizers, the inserting of questions, and the activation of prior knowledge.

Jonassen (1985) has used Rothkopf's (1980) 'mathemagenic' process to refer to this group of devices, contrasting them with 'generative' processes which he considers to be more in line with a cognitive approach to learning. According to Jonassen, the mathemagenic approach seeks to orient learners to the text and to show them what is relevant and important. Thus, it is, in essence, text control of the learning process. The generative approach, on the other hand, is held to emphasise not only learner involvement but learner control of the processes that produce comprehension. All of the devices referred to above have been considered by Jonassen as constructive mathemagenic strategies which address meaningfulness by attempting to orient learners to the textual content or by affecting the way they process it, whereas constructive generative processes are intended, primarily, to increase the meaningfulness of textual content.

Generative Processing	Mathemagenic Processing
Constructive	Constructive
Notetaking	Instructional objectives
Paraphrasing/summarizing	Branching programmed instruction
Synthesizing	Advance organizers
Generating questions	Inserted questions (pretest)
Imaging/illustrating	Titles/headings/markers
Mapping/networking	Graphic organizers
Learner control	Text control

This dichotomy is based on the work of Wittrock (1974) with respect to a generative model of learning which suggests that reading comprehension is facilitated when, during encoding, learners use their memories of events and experiences to construct meanings for the text. The actively constructed individualised meanings represent each learner's comprehension of the text, a view which is consistent with the schema-theoretic view of reading comprehension. Later work on generative processes (Doctorow, Wittrock & Marks, 1978) indicates that generative processing involves instructions to the reader to generate associations among words, to generate pictures and to generate meaningful elaborations, activities which go beyond the constructivist schema-theoretic view of reading comprehension. In this case of 'generative' learning, the reader is not only generating meaning, but generating overt performance which can contribute to learning. Jonassen's constructive mathemagenic and constructive generative terms certainly distinguish between those activities of constructing meaning and the overt articulation of that meaning, but the conclusion that the former is an example of 'text control' while the latter is an example of 'learner control' does not seem to be justified. Both involve cognitive processing in which the learner is in control, but the former could be referred to as 'text-induced' cognitive processing.

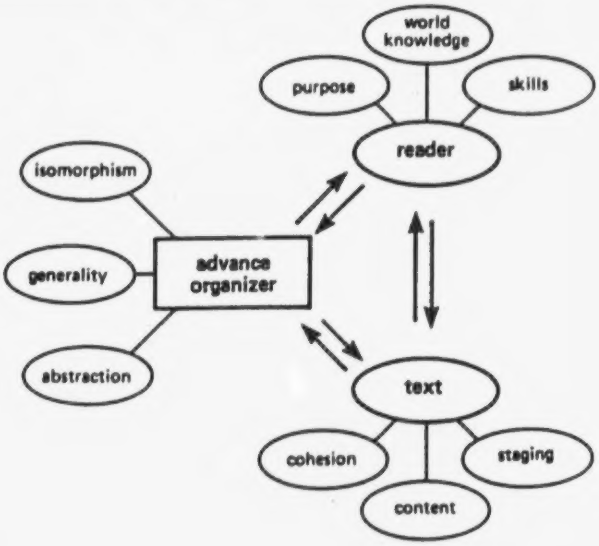
It is in that context that the role of adjunct aids is reconsidered.

(a) *advance organizers*

Anderson (1984) has claimed that schema theory supports the practice of providing advance organizers or structured overviews along the lines proposed by Ausubel whom he regards as one of the pioneer schema theorists, although he has reservations about Ausubel's insistence that organizers must be stated at a high level of generality, abstractness, and inclusiveness.

There seems to be little point in debating the precise nature of an advance organizer. The suggestion that "if it works, it is an advance organizer" is worth considering, whether the degree of abstractness or generalisability necessary for a true organizer has been demonstrated. Perhaps the phenomenon of success is more important. Thus, if verbal material provided prior to the main text is able to activate schema and prior knowledge in the reader, and is able through this and through its own structure to set the framework and organisation of the following text, then it is creating a 'set to learn' context and is, in a real sense, an advance organizer.

Stewart (1986) proposed a diagrammatic representation of the system which could account for the possible functioning or malfunctioning of advance organizers. In the



system, the text is the starting point since it is the first part of the system to be created. From the text, the advance organizer is developed, then the reader interacts, first with the advance organizer and then with the main body of the text.

- The text

The way in which the text is written, ie the way in which the content is treated with respect to top-level structure etc, the way in which main features are highlighted, and the way in which cohesion is achieved, will affect not only the comprehension process as the reader reacts with the text, but will also affect the possibilities for the construction of the advance organizer. The text, therefore, may be well structured or poorly structured with respect to all three variables, or it may be anywhere in between.

- The organizer

Whether it is prepared in accordance with Ausubelian parameters or not, the *de facto* advance organizer may extend from a single word (as in a title) to, perhaps, a 1000 word mini-discourse and, within that continuum, may have a varying degree of isomorphism (ie the extent to which it reflects the structure of the text), and may have varying degrees of generality and abstraction.

- The reader

The advance organizer will probably be the first part of the printed material to be read by the reader, and the parameters affecting his/her ability to interact with and learn from text are really just as important in interacting with and learning from the advance organizer (cf Dinnel & Glover, 1985). The reader may or may not have the pre-requisite world knowledge, the declared purpose for reading, or the developed strategies and metacognitive skills necessary to benefit from the advance organizer and, subsequently, from the text.

The many variables, often internally infinitely variable, make it virtually impossible to be definite about when advance organizers will or will not be effective. Nevertheless, having regard to the research evidence concerning advance organizers in relation to prior knowledge and schema theory, Stewart (1986) proposed the following general principle:

> "If the reader is oriented by a brief verbal organizer toward the application of existing knowledge to the assimilation of the main features of new knowledge in text, then comprehension of that new knowledge will be facilitated".

This principle, when put into practice, requires an approach to the design of advance organizers which is significantly different from current practice in that there is an overt emphasis on the acitivation of existing knowledge which, within a traditional approach, might have occurred only because it happened to be part of the way in which advance organizers operate. Making explicit a need to activate prior knowledge is really guidance to the reader, as is the linking of this to the main features of new knowledge in the text. The organizer with respect to the new knowledge is, however, more in line with the traditional approach to advance organizers. Conceivably, it would be possible to separate the 'guidance' from the 'organizer', but an integrated approach would probably be better and what is required is really an extension or broadening of the concept of advance organizer to include the element of guidance implicit in the identified principle.

(b) *graphic organizers*

From the published research relating to graphic organizers there are clearly two problems. First what can be classified as a graphic organizer and, second, the issue of pre- or post- application.

The second problem is more easily dealt with. Research which deals with graphic post-organizers also deals with reader-generated as opposed to author-provided organizers and, as has already been noted, this sort of activity involves the reader in a generative activity which could require a different level of cognitive processing since overt performance is required.

The first problem of definition is more difficult, but likely to be more useful if resolved. Based upon a verbal-pictorial continuum as proposed by Wileman (1980), Hawk, McLeod, and Jonassen (1985) have argued that graphic organizers can contain both pictorial (iconic sign) and verbal (digital sign) information and that, in accordance with Paivio's (1971) dual coding hypothesis, graphic organizers in text induce dual coding of information. Jonassen & Hawk (1983) have identified the need to ensure in a graphic organizer that the location of graphic elements depicting the main points and the way they are spatially related on an organizer corresponds to the semantic relationship between the 'main' ideas, and, also, that the graphic relationships are structurally isomorphic to the semantic relationships in the content, a point that has also been made by Schwarz & Kulhavy (1982).

What constitutes a graphic advance organizer is really any appropriate mixture of verbal and graphic material which relates to the structure of the text. At the intuitive level, there is a case for graphic organizers being particularly effective when the intention is to relate to structure because there is the potential not only to activate schema and indicate emphasis but, because of the possibility of dual coding or whatever other explanation there is for imagery, a higher level of cognitive operation, viz. relationship between ideas, can be presented as a starting point. It is doubtful whether there has yet been sufficient research carried out in this area. Nevertheless, from the available evidence relating to advance organizers in general and graphical organizers in particular, together with his own investigation, Stewart (1986) derived the following principle.

> "If a graphic organizer is used to convey isomorphically the structure of ideas in text, then comprehension of the structure will be facilitated".

Application of the principle concerning graphic organizers would require change in present practice for the obvious reason that the use of graphic organizers is a relatively rare occurrence. The development of a graphic organizer is a useful exercise when analysing already written text and can readily show up weaknesses and inconsistencies in the structure of the text but it is much more appropriate to try to develop the organizer based on the ideas and their relationships prior to their being put together in the text. The development of a graphic organizer is also a very useful stage in the development of typographical cueing devices since it can identify levels of headings and sub-headings. It really is surprising that graphic organizers are not more commonly found in instructional text considering that they may well have formed part of the author's working out of the ideas to be included in the text. It is because a graphic organizer can depict the structure of ideas in text, in the way that the author intended them to be related, that the graphic organizer is worthwhile adopting in practice.

(c) *adjunct questions*

Research into the effectiveness of adjunct questions has been concerned mainly with the position (before or after), type (factual or meaningful), and frequency of insertion. It has been observed by Linder & Rickards (1985) that all the investigations of Rothkopf (1965) began under the theoretical banner of neo-behaviourism but that recent subsequent research involving adjunct questions has assumed a cognitive perspective which emphasises the active and contructive role of the learner. Research in relation to adjunct questions appears to leave little doubt as to their effectiveness (Anderson & Biddle, 1975; Duchastel & Whitehead, 1980), but Resnick (1985) has noted that there seems to have been only slight progress in the direction of accounting for questioning effects in terms of cognitive processes.

It has been suggested by Hamilton (1985) that subjects normally process the passage at a very superficial semantic level and that verbatim questions, whether pre- or post- are answered on the basis of this level of processing. However, in the case of semantic questions, the pre-questions would not only focus the subject on the relevant prose material but also induce more than a superficial semantic level of processing of the target material, whereas post-questions would have minimal effects on the processing of the target material because they occur after the target material.

Linder & Rickards (1985) have argued that higher-level questions affect not only the level at which material is processed but the manner in which such material is organised in memory, and that higher-level questions therefore affect the quality as well as the quantity of recall. This is consistent with the 'qualitative outcomes of learning' research to be found among European educational researchers (Marton & Saljo, 1984; Entwistle & Ramsden, 1983; Saljo, 1984). If the reader can be induced through the adjunct questions to adopt a 'deep approach' to learning from that particular reading experience, then not only a deep semantic processing, but a more meaningful processing is likely to occur.

Setting the work on adjunct questions in that context led Stewart (1986) to derive the following principle.

> "If higher–level questions are inserted in text they are likely to induce a deeper level of processing on the part of the reader"

The key features of the principle relating to adjunct questions, as they affect educational practice, are the emphasis on questions being 'higher-level' and the outcome of their inclusion being a deeper level of processing. While the practice of including questions within text is not uncommon, such questions are often of a factual recall nature and not of the higher-level implied in the principle. No doubt there are times when factual questions are appropriate but where deeper levels of processing are intended, higher level questions need to be included.

(d) *learning objectives*

Hartley & Davis (1976) have noted that, despite a general lack of agreement as to the level of detail to which behavioural objectives should be written, the majority of studies have indicated that behavioural objectives provide a useful pre-istructional strategy. Hamilton (1985), however, has observed that objectives have consistently produced positive effects only for the retention of verbatim information while producing inconsistent effects for the retention of semantic verbal information. It appears, too, that this effect is in relation only to generally described goals or objectives and that the inclusion of other information consistent with the Magerian definition of objectives may, in fact, hinder the effects of the objectives.

To set the above in context, consideration needs to be given to the nature of the instructional objective or learning goal stated. In much of the research literature, many of the objectives have been low-level recall of information. It remains to be seen what would be the effect of a high-level objective. While an advance organizer may activate a particular schema or set of schemata, it is unlikely that the statement of an objective would have the same effect. What is much more likely is that the statement of a high-level objective (ie high-level in the Bloom or Gagne sense) would induce a set-to-learn from which deep processing would ensue. On this basis, Stewart (1986) proposed the following principle.

> "If a high-level learning outcome is stated as an objective in advance of reading, the learner is likely to adopt a deep approach to reading of the passage".

There does not appear to be any research which examines the effectiveness not only of high-level objectives but of high-level inserted questions which measure achievement of the high-level objectives. There is a strong relationship between the implications in practice of the above principle and those associated with the principle concerning inserted questions. In both cases a deep approach is expected. In practice it would be appropriate to implement both principles together by stating the high-level learning outcome in advance of the passage of text and including within the text high-level questions related to the stated learning outcome. Hopefully, the combined effect of both objective and question would be more certain than either independently and would, in fact, result in deeper processing.

Conclusion

It is unfortunate that the concept of mathemagenic activities has been so widely criticised, particularly when contrasted with so-called 'generative' processes. It was made clear by Rothkopf (1982) that the phrase 'mathemagenic activities' was coined to draw attention to the importance of readers' activities in learning from text because, at the time, practitioners and researchers were preoccupied with structural characteristics of text. It has also been made clear (Rothkopf, 1970) that the study of mathemagenic activities is the study of the students' actions that are relevant to the achievement of specified instructional objectives; that the concept of mathemagenic activity implies that a learner's actions play an important role in determining what is being learned; and that the most important determinant of the capabilities a student acquires from printed material is what the student does with the instructional materials.

This is not inconsistent with a cognitive, constructivist, view of reading comprehension, nor does it imply that control of the comprehension process lies in the text. Reading comprehension is an interactive process between reader and text and it is appropriate that verbal cueing (whether it be considered mathemagenic or not) should be used to facilitate achievement of the desired learning outcome. For the instructional designer, the reconsideration of adjunct aids as verbal cueing devices within a cognitive perspective of the reading process provides a defensible framework and challenges the designer to implement on a basis of principle rather than practice.

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Title:

Instructional Plans and Situated Learning: The Challenge of Suchman's Theory of Situated Action for Instructional Designers and Instructional Systems

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Instructional Plans and Situated Learning:

The Challenge of Suchman's Theory of Situated Action for Instructional Designers and Instructional Systems[1]

by

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Lucy Suchman is a researcher at Xerox PARC (Palo Alto Research Center) who studies how ordinary folks use Xerox machines that have built-in help and diagnosis programs. She distinguishes between *plans* (such as the hierarchy of sub-procedures for how Xerox machines should be used) and *situated actions* (i.e., the actual sense that specific users make out of specific Xeroxing events) and concludes that a theory of situated action is more true to the lived experience of Xerox users than a cognitive account of the user's plans (Suchman, 1987). Her distinction has profound implications for the discipline of Cognitive Science because cognitive scientists assume that plans are the essence of human actions. This assumption will be described throughout the paper as part of the cognitivist paradigm.

Suchman's distinction also poses a challenge for cognitively based Instructional Design because it leads to the following question: Do human beings such as teachers and learners follow plans (no matter how tentative or incomplete those plans might be) when they solve real-world problems or do human beings develop embodied skills that are only prospectively or retrospectively represented by plans? Suchman argues for the latter formulation. The question then becomes:

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Should instructional plans (e.g., drill-and-practice or expert tutoring instructional strategies) be designed into instructional systems in order to control instructional interactions when the users of such systems learn in a situated-action manner and not in a plan-based manner? Furthermore, should any theory (i.e., instructional or learning theory) be used to guide the actions of teachers or learners?

The remainder of the paper will discuss Suchman's ideas about plans and situated actions as well as the implications of these ideas for the design and use of instructional systems. The paper will end with a brief discussion of John Seely Brown's extension of Suchman's ideas and a general set of recommendations for instructional designers who want to remain sensitive to the epistemology of situated learning.

Plans and Instructional Systems

Cognitive science is an emerging specialty within educational psychology that merges ideas from information processing theory with disciplinary knowledge from computer science and artificial intelligence. Cognitive scientists make a number of assumptions about the world in order to conduct "normal science" in the Kuhnian sense of the term (Kuhn, 1970). For example, cognitive scientists treat mind as "neither substantial nor insubstantial, but as an abstractable structure implementable in any number of possible physical substrates" (Suchman, 1987). Furthermore, cognitive scientists treat the human mind as nothing but mental operations that mediate environmental stimuli and transform mental representations into other cognitive structures called plans which, in turn, produce behavioral responses (Suchman, 1987). Figure 1 provides a brief summary of the cognitivist model of mind.

Insert Figure 1 about here

The cognitivist paradigm also permits cognitive scientists to define learning as a change in cognitive structure and to study various lawful ways in which environmental stimuli can be manipulated in order to establish new cognitive structures (i.e., symbolic mental representations) and new cognitive operations (i.e., cognitive information processing). At the heart of the cognitivist paradigm, therefore, is the belief that the mind is a formal symbol manipulator that transforms symbolic representations into plan-based behavioral responses.

Several things are worth noting about the cognitivist paradigm. First, the cognitivist paradigm goes beyond the behaviorist paradigm in that it claims learning to be *more than* changes in external behavior. Learning is defined as changes in cognitive structures as evidenced by changes in external behavior. Gagne expresses this cognitivist orientation when he uses the concept of learned capabilities in instructional design (Gagne, 1987; Gagne, Briggs, & Wager, 1988). Second, cognitive structures or plans are treated as the *causes* of behavioral responses. Environmental stimuli still play a role, but more as information and triggering stimuli, than as causes of behavior. The computer is the root metaphor for this point of view because computer programs are the clearest expression of how plans can use input data to control external actions (Pylyshyn, 1984). Finally, the cognitivist paradigm opens the door for conceptualizing teaching and learning in information processing terms (Streibel, 1986). Each of these points will be elaborated below.

Instructional design theories such as Gagne's theory take the cognitivist paradigm one logical step further by claiming an instructional plan can generate the appropriate environmental stimuli and instructional interactions and thereby bring about a change in the cognitive structures and operations of the learner (Gagne, 1987; Gagne, Briggs, & Wager, 1988). Changes in cognitive structures and operations are inferred from the appearance of new (but prespecified) behavioral responses. Reigeluth articulates this next logical step when he describes the *prescriptive* use of descriptive instructional theories (Reigeluth, 1983, 1987). Figure 2 shows a brief schematic of these ideas.

Insert Figure 2 about here

The cognitivist paradigm in instructional design also has a unified conception of the teacher and the learner. When instructional strategies are embodied in an instructional system, instruction is viewed as an information process that is coupled with the learner's cognitive processes via environmental stimuli. The essential aspect of the teacher, therefore, resides in the knowledge structures and instructional plans that he, she, or it (i.e., instructional system) contains. The essential aspect of the learner resides in the new cognitive knowledge structures and operations that he, she, or it (i.e., machine learning system) constructs. Instructional plans in the teacher and cognitive operations in the learner here are both conceptualized in information-processing terms. Figure 3 spells out this reconceptualization.

Insert Figure 3 about here

The logical extension of the cognitivist paradigm described above does not imply the instructional plan in the instructional system *causes* the changes in the learner's behavior. The learner is not a *tabula rasa* as in the behaviorist paradigm (Mackenzie, 1977). Rather, the *interaction* of the learner's cognitive operations within the entire process of the instructional system leads the learner to *construct* new cognitive structures and operations. The cognitivist paradigm remains fundamentally constructivist and individualistic as Piaget has shown in several of his writings (Piaget, 1968).

Finally, the cognitivist paradigm permits one to posit that behavioral responses and cognitive structures and operations can be prespecified because both the teacher, the learner, and their interaction are theoretically described in identical information-processing terms. Suchman's discussion about plans and situated actions will question the whole cognitivist paradigm on this very point: Can the cognitivist paradigm provide an adequate conceptualization of human teaching and learning when these activities are fundamentally context-bound, situational activities and not context-free, plan-based activities? What is the problematic?

The Problematic of Plans and Instructional Practice

The problematic in the cognitivist scheme of things resides in the relationship between plans and situated actions *when human beings are involved*. The pivotal point of the problematic centers on the notion of interaction. According to Suchman, the traditional notion of interaction revolves around the concept of "communication between persons" (Suchman, 1987). However, in the cognitivist paradigm, interaction is restricted to the physical science concept of "reciprocal action or influence." A human learner who wants to work within an instructional system therefore has to assume the ontology of a machine for themselves in order to "learn" from the machine (Streibel, 1986). That is, a learner has to act as an information processor in order to "interact" with an instructional system. This result is a direct consequence of the cognitivist view of mind which separates meaning, imagination, and reason from a bodily basis (Johnson, 1987). This result, however, also places the human learner in a bind: Plans are generic and work with typical situations whereas purposeful actions such as learning are unique and interpreted in the context of specific interactions. Figure 4 shows the generic dimensions of instructional systems.

Insert Figure 4 about here

Put simply, the assumptions of the cognitivist paradigm conflict with the "life world" of the human learner because each learner brings a unique biography and history to each new learning experience and because each new learning interaction entails a unique, context-bound, sense-making process. Whereas a cognitive model of human learning is a rational reconstruction of minimally situated actions, the "life-world" of human learning is phenomenologically and contextually bound. Whereas a cognitive model of the processes of human learning is mechanical, the actual processes of human learning are experiential. And finally, whereas plans determine the meaning of actions in the cognitive model of human learning, the *in situ* interpretations of lived experiences by the participants determine the meanings of actions in the "life-world" of situated actions. A generic instructional plan in an instructional system can control a cognitive model of human learning but it cannot control the "life-world" of situated learning. Figure 5 summarizes the dimensions of the dilemma.

Insert Figure 5 about here

The problematic described above can be formulated as a question: Can human beings reason and learn in a situation where they have to deny the contextual nature of their thinking and knowing? Lucy Suchman provides a provocative answer: All real-world thinking and knowing (and learning) entails a form of context-bound and embodied, situational action and not plan-based interaction. Let's look at her arguments more closely.

"All activity, even the most abstract," claims Suchman, "is fundamentally concrete and embodied" (Suchman, 1987). Furthermore, "all purposeful actions...[are] inevitably situated actions...and primarily *ad hoc*." By "situated actions," Suchman means simply "actions taken in the context of particular, concrete circumstances." This being the case, "plans as such neither determine the actual course situated actions nor adequately reconstruct it" (Suchman, 1987).

I first encountered the problematic relationship between plans and situated actions when, after years of trying to follow Gagne's theory of instructional design, I repeatedly found myself, as an instructional designer, making ad hoc decisions throughout the design and development process. At first, I attributed this discrepancy to my own inexperience as an instructional designer. Later, when I became more experienced, I attributed it to the incompleteness of instructional design theories. Theories were, after all, only robust and mature at the end of a long developmental process, and, instructional design theories had a very short history. Lately, however, I have begun to believe that the discrepancy between instructional design theories and instructional design practice will never be resolved because instructional design practice will always be a form of situated activity (i.e., depend on the specific, concrete, and unique circumstances of the project I am working on). Furthermore, I now believe instructional design theories will never specify my design practice at anything other than the most general level.

My experience as an instructional designer raises a deeper question: Does the problematic relationship, which exists between instructional design theory and practice, also hold for instructional theories and practice? That is, is there a problematic relationship between an instructional strategy or plan embedded in an instructional system and the resulting instructional practice. Furthermore, is there a problematic relationship between learning theories and learning practice? I have no doubt that instructional theories and learning theories are legitimate abstractions from, and rational reconstructions of, instructional and learning actions. However, I am beginning to question whether instructional theories or learning theories should be used to develop plans to prescribe instructional and learning actions. This dilemma is particularly poignant because I have been professionally trained to believe that:

1. an instructional strategy can and should be designed into an instructional

system,

2. an instructional strategy or plan in an instructional system is the best (and some would say only) hope for guaranteeing a change in the cognitive structures and operations of the learner (Heinich, 1988).

Lucy Suchman's ideas help clarify the problematic as well as help reframe the problem.

Plans and Situated Actions

Suchman first analyzes how plans are conceptualized in the cognitivist paradigm and then describes an alternative paradigm for how plans actually operate in human beings. In the cognitivist paradigm, plans are believed to be "prerequisite to and prescriptive [of] action, at every level of detail," because the "organization and significance of human action [resides] in [the] underlying plans" (Suchman, 1987). Furthermore, in the cognitivist paradigm, mutual intelligibility between human beings reduces to (Suchman, 1987):

> A matter of reciprocal intelligibility of our plans, enabled by common conventions for the expressions of intent, and shared knowledge about typical situations and appropriate actions.

Shared knowledge structures, typical situations, and appropriate actions are, therefore, external and prior to the same things in other people. Furthermore, two people can only understand each other when they share the same symbolic representations about typical situations and appropriate actions. Intent here is tied to the plan of action for typical, and therefore context-free, situations. Figure 6 sketches out these ideas.

Insert Figure 6 about here

The problematic in the cognitivist point-of-view arises because the lived experience of two persons are not made up of identical representations. Suchman's argument here is ultimately based on an appeal to experience because human beings have no privileged way of knowing whether an identity relationship exists between the cognitive representations of different people. Our phenomenological experience, on the other hand, tells us that our knowledge always entails specific, contextual experience, and our actions always proceed on the basis of context-sensitive, embodied skills and not rationally-constructed plans.

Suchman clarifies the problematic between plans and situated actions by claiming that (Suchman, 1987):

> While the course of action can always be projected or reconstructed in terms of prior intentions or typical situations, the prescriptive significance of intentions for situated actions is inherently vague...because we can state our intentions without having to describe the actual course of events.

Plans, in other words, say more about our reasoning about action than about the actual course of events. Suchman, therefore, claims that (Suchman, 1987):

> The coherence of situated actions is tied in essential ways not to individual predispositions or conventional rules but to local interactions contingent on the actor's particular circumstances.

Let us use our example of a learner interacting with an instructional system. Extrapolating from Suchman's arguments, the coherence of the learner's experience in this situation is not tied in essential ways to the instructional designer's intent (no matter how detailed or explicit these intentions are spelled-out as instructional objectives) nor to the instructional plan built into the instructional system. Rather, the coherence of the learner's instructional experience is tied to the sense that such a learner constructs out of the actual situation (of which the instructional system is just a part). Hence, the sense that this learner at this point in time and in this situation will make out of the learning situation cannot be predicted or even assumed to be understood by an instructional designer who is not part of the actual situation. The best an instructional designer can do is create an instructional environment where the learner's processes of situational sense-making are enhanced. What does this mean for an instructional designer? Suchman again provides a tentative answer.

Suchman considers face-to-face human interaction to be the "paradigm case for [all] communication...[because it is] organized for maximum context sensitivity" (Suchman, 1987). Furthermore, face-to-face communication "brings that context-sensitivity to bear on problems of skill acquisition...for just those recipients on just those occasions" (Suchman, 1987). Face-to-face human communication therefore becomes the means through which actions in a unique situation for unique a learner are connected to larger personal and interpersonal interactions and thereby made mutually intelligible. In her own research on how novices learn to use Xerox machines, Suchman has users team up and engage in a conversation with each other about the concrete situation. Meanings are constructed and negotiated in an ongoing dialogue, and the plans that the Xerox machine happens to contain are only treated as resources. Furthermore, sense making is intimately tied to the resolution of emergent dilemmas by each group of users. Suchman therefore concludes that the "conversation" between the users gave coherence to their situation rather than the plans built into the Xerox machines. John Seely Brown has taken Suchman's ideas and generalized them to encompass everyday cognition (Brown, 1988). See Figure 7 for a brief outline of these ideas.

Insert Figure 7 about here

What roles should plans play in the context of situated actions? For our purposes, what role should instructional plans play in the actual operation of instructional systems? Based on our discussion so far, we can begin to draw some tentative conclusions. First, we should stop treating plans as mechanisms that bring about subsequent actions:

1. in the case of human beings, plans should not be treated as "psychological mechanisms" that control and give meaning to subsequent behavior. Rather,

plans should be treated as "artifact[s] of our reasoning about actions." (Suchman, 1987)

2. in the case of instructional systems, instructional plans should not be used to control instructional interactions. Rather, plans should be used for:
   a. communicating about situated actions with other human beings,
   b. reflecting on and reconceptualizing situational actions.

In short, instructional plans should be used by both instructional designers and instructional users as resources for future situated actions.

What do these tentative conclusions imply? How can one design instructional systems where instructional plans operate as resources for the learners and not as controlling mechanisms? Suchman's situated-action paradigm again helps clarify the relationship between plans and situated learning.

Plans and Situated Learning

What has Suchman concluded so far? First, she has claimed that "every course of action depends in essential ways upon its material and social circumstances" (Suchman, 1987). Second, she has claimed that face-to-face communication and collaborative action are essential for sense-making in any situation. Finally, she has claimed that our knowledge of the physical and social worlds is inter-subjectively constructed by us. On the most general level, therefore, we can no longer view instructional systems as mechanisms that transmit knowledge or train skills in an information-processing sense of the term. Plans can play a communicative role but not a constitutive role in instructional interactions. To understand this more deeply, we have to examine Suchman's main propositions about plans.

First, Suchman admits that plans are representations of situated actions. However, these representations always come "before the fact in the form of imagined projections or recollected reconstructions" rather than as controlling procedures during situated actions (Suchman, 1987). Hence, "plans orient us in situated actions" rather than prescribe the sequence of actions. Instructional strategies should, therefore, only be used to orient future teachers or learners for situated learning and not prescribe how to teach or how to learn. The actual embodied skills of teaching or learning still have to be worked out by the teacher or learner. In the case of instructional designers, instructional plans should only be used as general resources for the design and development of instructional systems. In the case of the operation of instructional systems, the instructional strategy should not control the actual instructional interaction. Finally, in the case of the human learner, the instructional strategy should be used to orient the human learner towards the material rather than controlling and evaluating each behavior. The instructional system in this scenario would act more like a coach than an instructor or tutor, and the human learner's role would be more that of a self-teacher than of a student. Figure 8 summarizes this point.

Insert Figure 8 about here

Is the foregoing suggestion about instructional systems a romantic ideal? Is it unrealistic? No, because the actual reality of designing an instructional system will always turn out to be a form of situational action. "When it comes down to the details," writes Suchman, "you effectively abandon the plan and fall back on whatever embodied skills are available to you" (Suchman, 1987). The same can be said for instruction and learning. When an instructor or a learner gets down to the details of teaching or learning, the respective theories of instruction or learning are abandoned and the instructor or learner falls back onto his or her embodied skills in the situation. An instructional designer would, therefore, do well to provide the learner, using an instructional system, with the appropriate resources to develop the learner's embodied self-teaching skills.

The suggestion that instructional systems should help learners develop embodied learning strategy skills sounds remarkably like the rhetoric about learning strategies design (O'Neil, 1978; O'Neil & Spielberger, 1979). However, one cannot design plans to instruct learning-strategy skills either. Suchman clarifies this point by saying (Suchman, 1987):

> It is frequently by only acting in a present situation that its possibilities become clear....In many cases, it is only after we encounter some state of affairs that we find to be desirable (e.g., a 'teachable moment' in a classroom for a teacher) that we identify that state as the goal towards which our previous actions, in retrospect, were directed all along.

An instructional designer cannot therefore predict which aspect of the instructional plan or which feature of the instructional system will be interpreted by the learner as a learning event, and so cannot design a plan for developing learning strategies. An instructional designer can, however, create a learning environment where learning strategies are used as resources by the learner. In a computer-based reactive learning environment called MENDEL which I and my colleagues are developing at the University of Wisconsin, a computer program helps students compare their intermediate hypotheses about genetics experiments against the data that the computer generates (Streibel et al., 1987). The program does not tutor students about the procedures or solve the problems for them, rather it offers advice on how to check their ideas. The program does this in spite of the fact that it contains an expert systems component that could solve the problem the student faces in a more efficient manner. The distinction between a plan as an instructional algorithm and a plan as an instructional resource is a very subtle one but it definitely runs counter to Richard Clark's suggestion that the instructional design component of instructional systems is the most efficacious component as far as learning is concerned (Clark & Salomon, 1986).

Suchman also argues that plans are only constructed by people in actual situations when (Suchman, 1987):

> Otherwise transparent [i.e. situational] activity becomes in some way

> problematized...[That is], when situated action becomes in some way problematized, rules and procedures are explicated for purposes of deliberation [and communication] and the action, which is otherwise neither rule-bound nor procedural, is then made accountable to them.

Note that representations here do not stand in an essential relationship to actions. Rather, plans are social and rational reconstructions of problematized situated actions.

Teachers in the critical pedagogy and experiential learning traditions have long known how to problematize learning situations and use reflection to turn experience into further action (Shor, 1980; Kolb, 1984; Boud et al., 1985; Livingston et al., 1987). In each of these traditions, teachers use face-to-face dialogue in order to problematize some part of the world and then use reflection as a way to get beyond the immediate situation. Furthermore, in each of these cases, teachers develop a dilemma language with the learners in order to foster mindful action (Berlak & Berlak, 1981). The key elements in the critical pedagogy and experiential learning traditions that develop embodied skills are, therefore, context-bound discourse-practices, negotiation of the very language used to characterize and resolve dilemmas, and reflective action. Both discourse-practices and reflective actions go beyond any rules and procedures.

Instructional designers face a serious challenge from the critical pedagogy tradition because instructional designers are neither part of the actual instructional interaction that they create, nor are they able to articulate a plan to help students problematize, analyze, and reconceptualize the "life-world" of the learning situation. At best, instructional designers can only create simplified reactive learning environments where students work collaboratively to resolve artificial dilemmas.

Suchman's third proposition about plans and situated actions claims that "the objectivity of the situations in our actions is achieved rather than given" (Suchman, 1987). An instructional system that operates according to a plan made prior to face-to-face interaction, therefore, undermines the very processes by which the objectivity of the physical and social worlds is apprehended by new learners. In the place of interpersonal construction of reality, such instructional systems offer a coercive rather than a constructive interaction. What can an instructional designer do about this? How can an instructional system avoid coercive interactions?

George Herbert Mead argued, as early as 1934, that the physical and social worlds are "constructed by us through language" (Suchman, 1987). It is therefore, through the medium of language, that a learner will construct and construe the objectivity of some part of the physical and social worlds. However, language is not a set of symbols communicated through a medium. Language itself is constructed out of social discourse-practices. It is therefore not enough for an instructional designer to simply communicate messages about the physical and social worlds to the learner via the instructional system. Such a point of view would still legitimize coercive communication. Suchman helps clarify this point.

"Our everyday practices," writes Suchman, "render the social world publicly available and mutually intelligible" (Suchman, 1987). Hence:

1. the objectivity of the physical and social worlds is "the product of systematic practices" (Suchman, 1987).
2. the source of the mutual intelligibility:
    a. does not rest on "pre-existing conceptual schemes,"
    b. is not the result of "a set of coercive rules or norms,"
    c. is based on a "common practices that produce typifications" (Suchman, 1987).

The best way to help learners make sense out of their learning situations is, therefore, to help them approach the learning situation as ethnographers. A learning situation is, after all, a kind of social practice, and learners are, in effect, in the position of field workers who want to get into the disciplinary subculture's lore of knowledge. Ethnomethodologies are useful for learners because they deal with "how members of a group make sense" and "how...objectivity and mutual intelligibility [are] achieved" (Suchman, 1987). An instructional designer who wants to address the constraints of situational learning will therefore have to find ways of creating instructional systems that give learners a chance to act as ethnographers.

Suchman's final proposition about plans and situated actions deals with how "language...[is] a central resource for achieving the objectivity of situations." (Suchman, 1987):

> Language [she writes] is a form of situated action because the significance of an expression always exceeds the meaning of what actually gets said. The interpretation of an expression depends not only on its conventional or definitional meanings, not on that plus some body of proposition, but on the unspoken situation of its use.

Hence, plans which try "to guarantee a particular interpretation" by providing "exhaustive action descriptions" are bound to fail because (Suchman, 1987):

> There [are] no fixed set of assumptions...or background knowledge that underlie a given statement...[Hence] mutual intelligibility is achieved on each occasion of interaction with reference to situational particulars.

Suchman continues by claiming that "interpreting the significance is an essentially collaborative achievement" (Suchman, 1987). Mutual intelligibility, in fact, requires constant collaborative conversation. The reasons for this are simple. The significance of our everyday interactions contain inevitable uncertainties and our language entails inevitable miscommunications. The only way to catch these uncertainties and repair these miscommunications is to conduct constant and in situ conversations. Interactive instructional systems, even those that use artificial intelligence technologies to model the communications process, are of no help here because (Suchman, 1987):

> There is a profound and persisting asymmetry between people and machines, due to a disparity in their relative access to moment-by-moment contingencies that constitute the conditions of situated actions.

Human teaching and learning, therefore, require the presence of face-to-face linguistic engagement. Suchman's conclusion is all the more significant because she applies it to the acquisition of a simple procedural skill (i.e., how to use a Xerox machine).

John Seely Brown's Epistemology of Situated Learning

So far, I have described Lucy Suchman's theory of plans and situated actions, and applied her ideas to the design and use of instructional systems. I would now like to end with a brief discussion of the epistemology of situated learning in order to give some direction for further work in this area. My task has is made easier by John Seely Brown who has generalized Lucy Suchman's ideas.

John Seely Brown is a colleague of Lucy Suchman at Xerox PARC and one of the founders of the field of Intelligent Tutoring Systems. Intelligent Tutoring Systems are the most sophisticated forms of instructional systems and incorporate ideas from cognitive science, computer science, and artificial intelligence.

John Seely Brown also studied how human beings actually learn in the presence of intelligent tutoring systems and concluded that Suchman's theory of situated action was a more adequate account of the phenomena than a cognitive theory of plans. He therefore began to formulate an epistemology of situational learning that is sensitive to the nature of situational action.

Brown first spells out how ordinary folks think about real-world problems. Ordinary folks, says Brown, (Brown, 1988):

1. act on concrete situations,
2. resolve emerging dilemmas,
3. negotiate the meanings of terms used to describe new situations,
4. and ultimately use socially-constructed plans as resources for each new situation.

Figure 9 summarizes some of these conclusions.

Insert Figure 9 about here

Brown then compares everyday cognition with expert cognition. Experts, according to Brown, are persons who have acquired a disciplinary subculture of knowledge and discourse-practice. The most interesting aspect of Brown's comparison is that everyday and expert cognition have very much in common. According to the cognitivist paradigm, however, expert plans and procedures are the very thing that distinguish experts from ordinary people. According to Brown, on the other hand, the only difference between expert and ordinary people is that experts have a set of model through which they act on situations; whereas, just plain folks act on situations with partial, and often incorrect, models. Both experts and everyday folks mix knowledge with use and belief in real-world situations and both socially-construct the objectivity of knowledge. Furthermore, everyday folks become experts through a socialization process of acquiring effective discourse-practices in situated actions just as experts do. Everyday folks do not become experts by acquiring expert knowledge or following expert rules (Dreyfus & Dreyfus, 1986)

Brown then spells out the epistemological shifts that take place when we move from a cognitivist paradigm to a situated learning paradigm. Figure 10 summarizes these shifts (Brown, 1988). I will only highlight those aspects of the paradigm shift that have a direct bearing on the design of instructional systems.

Insert Figure 10 about here

The most obvious epistemological shift is from knowledge to practice. Learning is no longer a matter of ingesting externally-defined, decontextualized objects, but a matter of developing context-bound discourse-practices. This means the objectives of an instructional system can no longer be seen as a pre-defined end-point for learning, nor instructional tasks as a sine qua non of instructional interaction. Rather, objectives can only be seen as expectancies that constrain the direction the learner is going, and instructional tasks can only be seen as one of many activities the learner might choose to pursue.

The second epistemological shift is from problem-solving to dilemma-handling. This means that learning can no longer be viewed as a form of cognitive problem solving, but as a form of posing problems, formulating hypotheses and terms to handle the problem, negotiating criteria to evaluate the problem, and finally interpersonally resolving the problem. In some ways, the very word "problem" is inadequate in the situated learning paradigm because it reduces real-world dilemmas to cognitive puzzles that have an explicit solution built into them. Hence, the word "dilemma-handling" is a more adequate term.

The final shift that I want to mention involves the move from efficiency to rationality. Cognitive-based instructional systems, as I have shown in an earlier paper, are ultimately shaped by the economic criteria of systems efficiency rather than the qualitative criteria of excellence and substantive understanding (Streibel, 1986). Cognitive-based instructional systems, therefore, serve the "human interests" of someone other that the learner (Apple, 1975; Wolcott, 1977; Bullough, Goldstein, & Holt, 1984). In the situated learning paradigm, however, the learner is at the center of negotiating the meaning of their actions and therefore at the center of negotiating what is rational to them. An instructional system that is sensitive to the situated learning paradigm has to respect and encourage the very social-linguistic processes by which rationality is constructed. This is a tall order for instructional systems, even those as advanced as intelligent tutoring systems, because such systems have a very limited access to the "moment-by-moment contingencies that constitute the conditions of situated actions (Suchman, 1987). It is, however, a challenge that we as instructional designers will have meet if we are to respect the way human beings actually learn.

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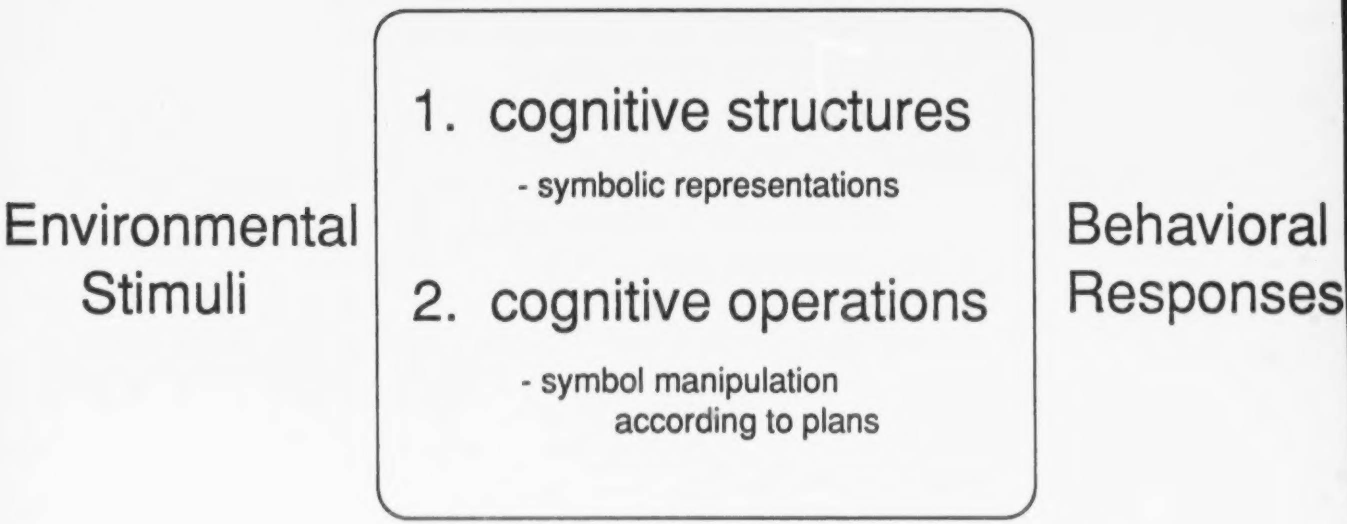
Cognitivist Paradigm



Mind

Environmental Stimuli

1. cognitive structures
   - symbolic representations
2. cognitive operations
   - symbol manipulation according to plans

Behavioral Responses

Figure 1

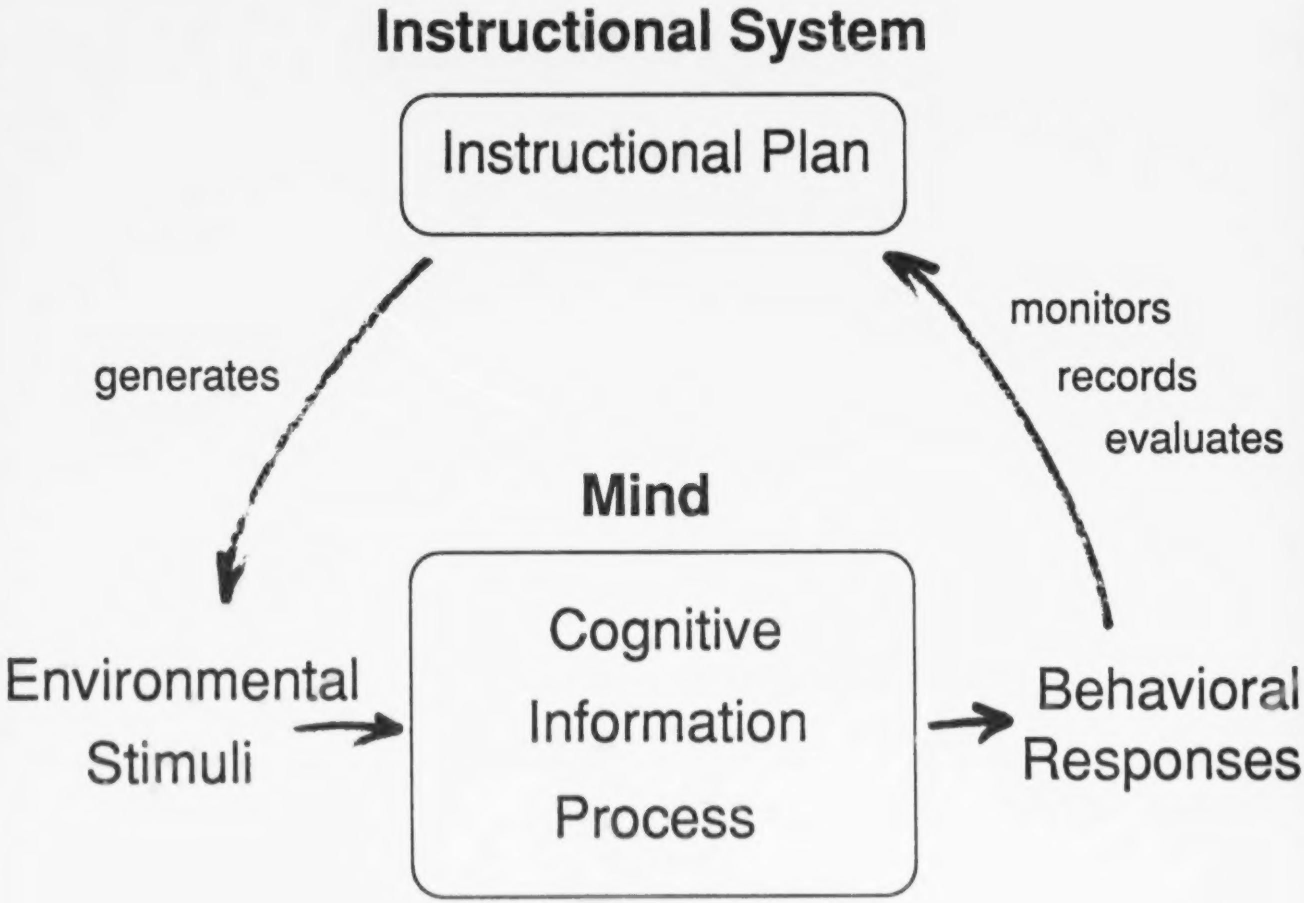

Instructional System
Instructional Plan
generates
monitors
records
evaluates
Mind
Cognitive Information Process
Environmental Stimuli
Behavioral Responses

Figure 2

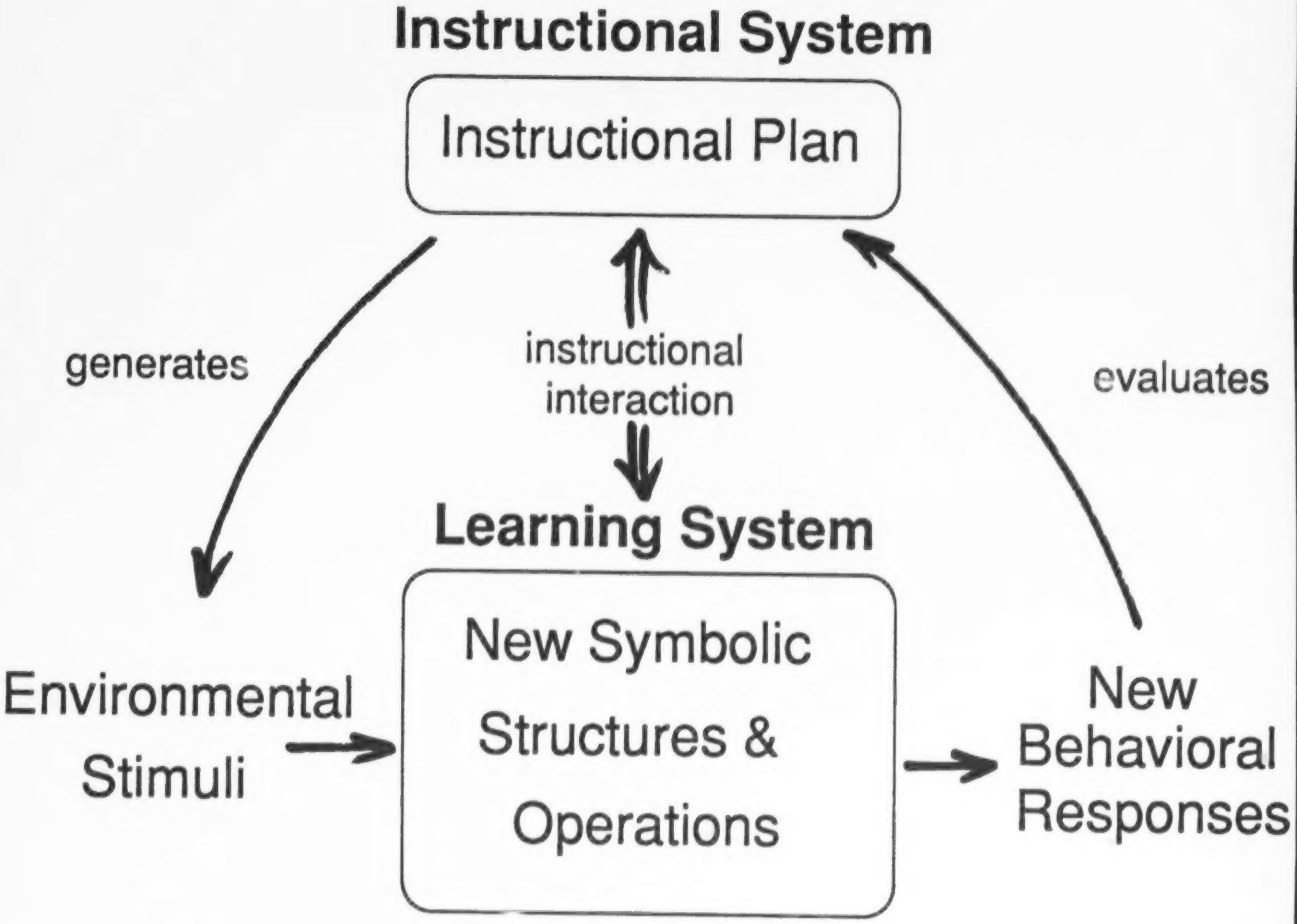

Instructional System
Instructional Plan
generates
instructional interaction
evaluates
Learning System
Environmental Stimuli
New Symbolic Structures & Operations
New Behavioral Responses

Figure 3

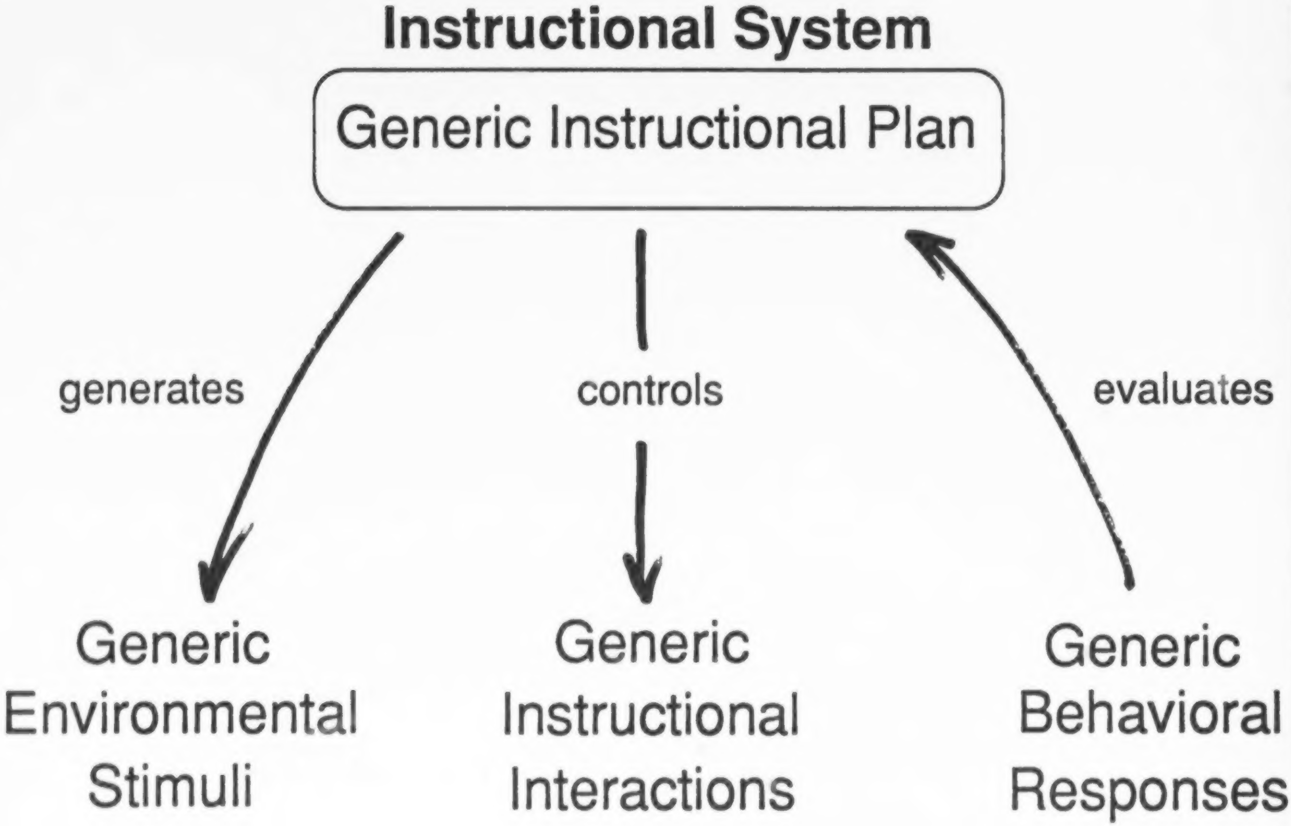
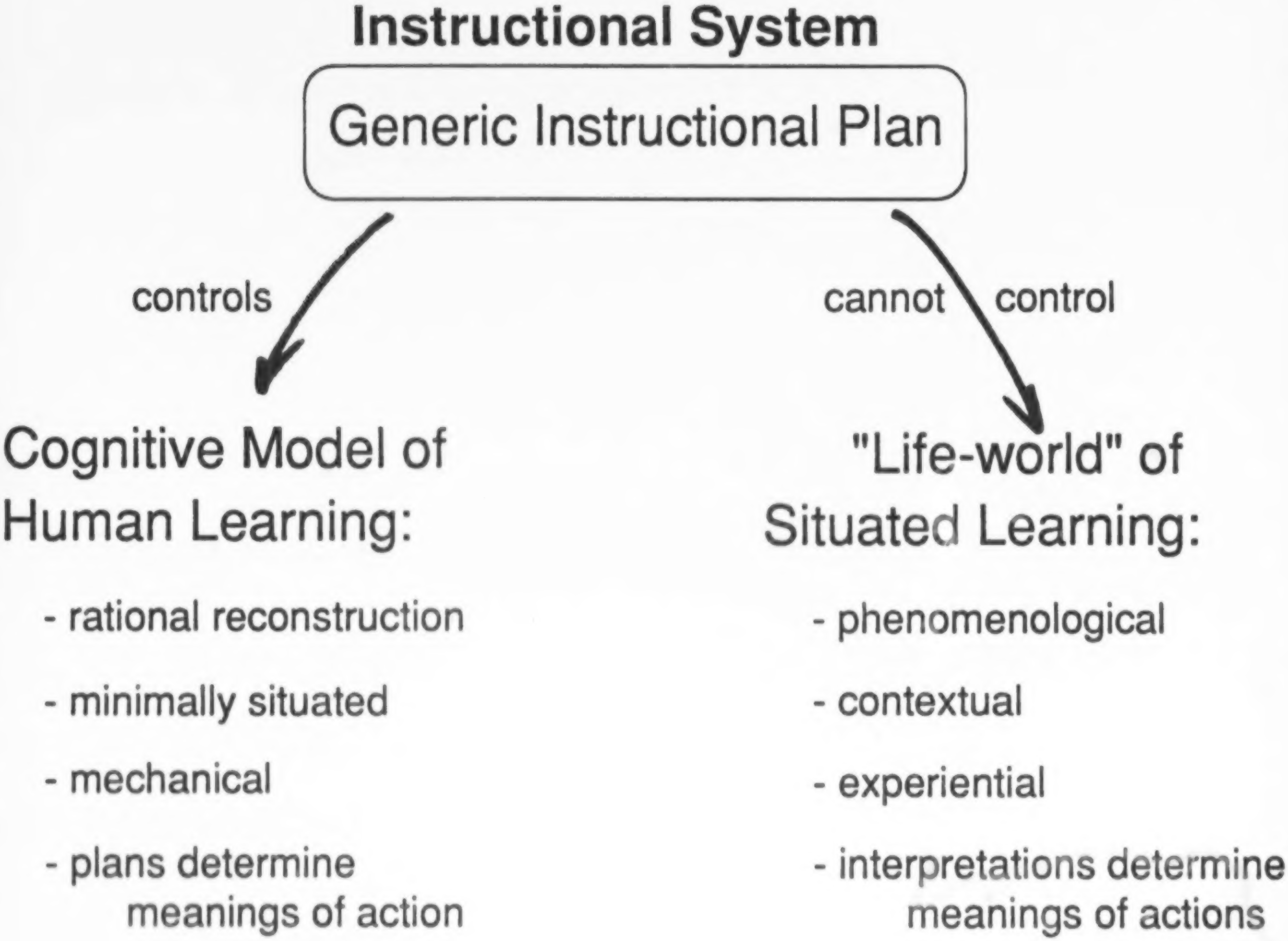

Instructional System
Generic Instructional Plan
generates
controls
evaluates
Generic Environmental Stimuli
Generic Instructional Interactions
Generic Behavioral Responses

Figure 4



Instructional System

Generic Instructional Plan

controls

cannot control

Cognitive Model of Human Learning:

- rational reconstruction
- minimally situated
- mechanical
- plans determine meanings of action

"Life-world" of Situated Learning:

- phenomenological
- contextual
- experiential
- interpretations determine meanings of actions

Figure 5

Cognitive Learning Paradigm	Situated Learning Paradigm
Plans:	Plans:
1. pre-requisite to action or prescriptive of action	1. imaginative projection of action or rational reconstruction of action
2. at the heart of: - the organization of action - the significance of action	2. at the heart of: - reasoning about action - communication about action
3. strong link to intention	3. weak link to intention

Figure 6

Aspects of Everyday Cognition

John Seely Brown

1. act on situations
2. make sense out of concrete situations
3. resolve emergent dilemmas
4. negotiate the meaning of terms
5. use plans as resources
6. socially-construct physical and social reality

↓

"conversation" with a situation

Figure 7

Situational-Learning-Based Instructional Systems

1. use plans as resources to orient the learner towards action
2. include face-to-face dialogue to develop embodied skills
3. help learners problematize a situation & resolve emergent dilemmas
4. help learners develop situated discourse-practices
5. use collaborative learning structures
6. use language to construct physical and social reality

↓

learners as "self-teachers" and "ethnographers"

Figure 8

Aspects of Cognition

John Seely Brown

Everyday Cognition	Expert Cognition
1. act on situations	1. see through symbols
2. contextual sense-making	2. contextual sense-making
3. resolve emergent dilemmas	3. resolve ill-defined dilemmas
4. negotiate meanings	4. negotiate meanings
5. use plans as resources	5. use plans as resources
6. socially-construct physical and social reality	6. socially-construct physical and social reality

expertise = acquiring a subculture

Figure 9

Epistemological Paradigm Shift

John Seely Brown

Cognitive Learning	Situated Learning
1. decontextualized	1. contextualized
2. knowledge	2. practice
3. goals	3. expectancies
4. tasks/problems	4. activities
5. solipsistic	5. interactional
6. formal	6. coordinated
7. definitional	7. constraints
8. problem-solving	8. dilemma handling
9. looking at	9. looking through
10. explicit theories	10. implicit theories
11. reference fixed	11. reference negotiated
12. efficiency	12. rationality

Figure 10

Title:

The Effects of MCBI Program Embedded Cognitive Strategies for Performance on Verbal and Visual Testing

Authors:

William Taylor
James Canelos
John Belland
Gary Mayton
Frank Dwyer

The Effects of MCBI Program Embedded Cognitive Strategies For Performance On Verbal and Visual Testing

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January 1989

Rationale & Related Literature

The present research study is an extension, and further refinement of a series of studies completed by the authors on micro-computer based instruction (MCBI) and cognition. Each of these research studies was designed to examine learning strategies and program embedded cognitive strategies to improve learning from MCBI. The first study examined a general learning strategy of program pacing, external-paced versus self-paced (Belland, et al 1985). While much of MCBI is oriented to provide self-paced instruction to adjust for individual differences, there is some indication from cognitive theory that self-paced may not be the best approach. For example, Wittrock (1979) noted that attention and motivation are key cognitive variables, indicating that as they are increased to optimal levels learning improves. Carrier also found that learners may not be the best judge of what to learn, when to learn, or how to learn new material (1984). The results of our first study supported these findings indicating that moderate levels of external pacing in the MCBI instructional program improves the amount learned and the competency level in using new material over self-paced MCBI.

Based upon these initial results, and research findings on other types of cognitive learning strategies (O'Neil 1978; O'Neil & Speilberger, 1978), two studies were designed to examine the effects of cognitive strategies (Canelos, et al, 1986; Taylor, et al, 1987). If a pacing strategy could improve learning it is likely that a cognitive strategy, based upon fundamental cognitive processes, could provide additional learning benefits when learning from MCBI. Two areas of research were considered to determine the types of learning strategies to be evaluated. The first was the research on imagery mediation (Paivio, 1970), the second on meaningful learning theory involving attention directing strategies (Ausubel, 1968).

Cognitive imagery mediation research has a long history stemming from early work by Paivio (1970), Harowitz (1970), and others, to current work on imagery learning strategies (Dansereau, 1978; Kosslyn, 1975). Imagery learning strategies, based upon imagery mediation, tend to significantly improve learning and later recall over the learner's own basic memory strategies. Similarly, research on attention directing strategies has indicated that learning can be improved significantly if learners are provided strategies that improve attending behaviors thus helping them separate relevant from background information (Rothkopf, 1967). This research base led to the development of two program embedded learning strategies: the imagery cue strategy, and the attention directing strategy. These two strategies were evaluated in our next two MCBI studies, presented at the 1986 and 1987 AECT conferences.

The 1986 (Canelos, et al) and 1987 (Taylor, et al) studies evaluated learning from MCBI, with the added effects of the imagery cue strategy and an attention directing strategy. Both of these strategies were program embedded, indicating that the learner did not have to learn a strategy, but used the strategy while working through the MCBI program. These strategies are described in detail in Taylor, et al (1987). Results of this 1987 study on MCBI, and program embedded learning strategies indicated that the imagery cue strategy significantly improved learning, as did the attention directing strategy. However, the imagery cue strategy seemed to be more effective overall, particularly for spatial tasks. An additional finding was that an external-paced MCBI condition was better overall, when using program embedded learning strategies. While these first three studies allowed the refinement and development of MCBI pacing strategies, and program embedded learning strategies, the effects of testing needs to be further examined. The research on encoding specificity has indicated that there is a significant interaction between elements in instructional conditions, and testing (Tulving, 1979). For example, if visuals are a significant part of instruction, but do not occur during testing, performance can be adversely effected (Canelos, et al, 1985).

The present study will further examine the effectiveness of an imagery program embedded learning strategy, and an attention directing program embedded learning strategy, when learning from MCBI. However, this study will evaluate the relationship between MCBI program embedded strategy use and a visual testing method and verbal testing method. The following research hypothesis will be evaluated by the experimental design in Figure 1.

1) The program embedded cognitive strategies will allow learners to acquire more information from the MCBI program, than their own cognitive strategies.

2) The imagery cue program embedded learning strategy will be more effective overall for learning, than the attention directing strategy.

3) Verbal and visual testing will interact with learning strategy type, yielding an encoding specifity relationship.

4) Verbal and visual testing will interact with the level of testing difficulty.

Experimental Design

Figure 1 outlines the experimental design used in this study. The MCBI instructional programs will instruct learners on the parts and operations of the human heart. There are 57 instructional frames in each program, consisting of a visual, verbal labels, a brief verbal description, activity questions, then feedback. The basic design of each MCBI program will use an externally paced learning strategy. Two of the MCBI conditions will include program embedded learning strategies. One MCBI condition will have an imagery cue strategy. The second program embedded strategy will be the attention directing strategy.

1) Externally Paced Program

The first instructional condition was externally paced. The external pacing began after the instructional display was completed. After each instructional display was completed, the computer timed the student's interaction with the completed display at a pace of: (1) one second per each line of verbal instruction, plus one second; so for five lines, six seconds for reading were given, (b) seven seconds for cognitive processing were then given; (c) after reading time and cognitive processing time had elapsed, the instructional display was removed from the terminal screen.

To move forward, the learner pressed the return key to receive the activity question. The learner had as much time as required to respond. If the correct answer was entered, simple feedback was given and the student moved to the next instructional display. If the incorrect answer was typed in, simple feedback was given that indicated an incorrect answer. The learner was given the option of receiving elaborate feedback, which was the repeat of the instructional display containing the required answer. The elaborate feedback was optional; the learner could move to the next instructional display or take feedback. Feedback was a repeat of the instructional display and was timed the same way.

2) Externally Paced Plus Imagery Cue Strategy

The second instructional condition was identical to the first instructional condition, but with the addition of the program embedded strategy of an imagery cue strategy. The instructional content and content sequence were identical. The imagery cue strategy was presented in a program embedded format. The imagery cue strategy was a special screen display occurring every 5-7 instructional displays, prompting the learner to form a mental image of the heart parts seen thus far.

3) Externally Paced Plus Attention Directing Strategy

The third instructional condition was identical to the first instructional condition, in terms of content and content sequence, but with the addition of the attention directing strategy. The attention directing strategy was a program embedded strategy. The attention directing strategy was a five second time delay which occurred in each instructional display, between the presentation of spatial information and the accompanying verbal descriptive information. This tended to increase attention to the visual information in the instructional display.

The testing condition in the experimental design has five visual and verbal tests to evaluate performance on five intellectual skills: list learning, simple concept learning, complex concept learning, cued recall, and problem solving. All testing at one level is visual, involving either a visual cue, visual problem or spatial relationship. In the second level of the testing condition all tests are verbal using either multiple choice, or requiring a verbal description to complete a problem. The visual and verbal tests evaluate performance on the same intellectual skills, with test items on each test being isomorphic. Each of the five tests has 20 possible points. The only difference between the testing conditions is the use of either visual or verbal information in the way the test item is structured and presented to the learner.

Verbal Testing Conditions

1) List Learning Tasks

The list learning task was a simple memory task, requiring the learner to list the names of the parts of the heart and phase names.

2) Cued-Recall Task, Verbal Orientation

The cued-recall task consisted of 20 multiple choice items designed to test the learning of heart part locations. The test contained a line drawing of the heart with numbers and arrows indicating where each part was located. The 20 multiple choice verbal test items appeared under the numbered drawing and required the subject to identify specific parts and locations. While there was a spatial cue given, the structure of each test item was verbal multiple choice.

Sample Item

Arrow number eight (8) points to the

a. pericardium
b. endocardium
c. ectocardium
d. ectoderm
e. myocardium

3) Simple Concept Learning Task

In each item stem, the simple concept learning task items provided a description of a critical attribute about a heart part or operation. The learner selected the the heart part name or operation name from the available choices.

Sample Item

The ____________________ is the name given to the inside lining of the heart wall.

a. epicardium
b. endocardium
c. pericardium
d. myocardium
e. septum

4) Complex Concept Learning Task

The complex concept learning task items were complex in the sense that they involved "if-then" relationships of the parts of the heart during heart operation.

Sample Item

When blood is entering through the vena cavas it is also entering through the

a. mitral valve
b. pulmonary veins
c. pulmonary artery
d. aortic arch
e. aorta

5) Problem Task Verbal, Free-Recall

The problem task verbal free recall was considered the most difficult of the five verbal tasks. The learner had to prepare from memory a detailed written description of the heart, with the parts described in the correct location and function as to how they operate. The learner has to also describe blood flow through the heart pump system and the heart phases. There were 20 possible points on this task.

Visual Testing Conditions

1) List Learning Task

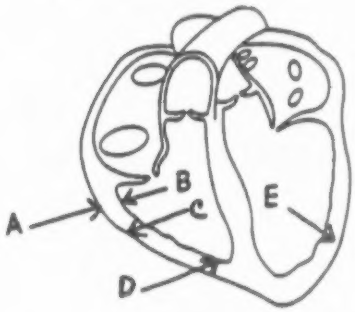
This task was the same for both types of testing, thus serving as a testing control for both groups, visual and verbal.

2) Cued-Recall Task, Visual Orientation

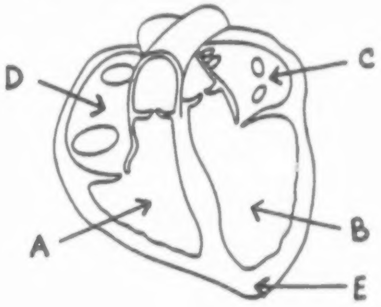
This task was visual in nature, but required similar knowledge as in its verbal task counterpart. The learner had to identify a heart part location, but in this case the test item was completely visual in structure.

Select the letter which correctly represents the part or function of the heart described in each question.

13. myocardium



14. left ventricle

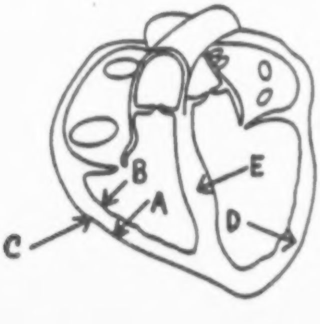


3) Simple Concept Learning Task

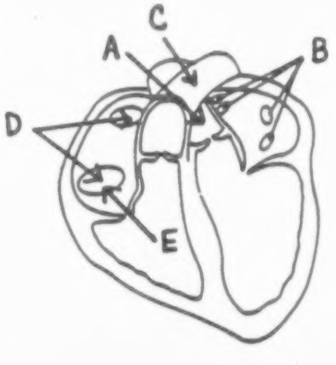
Again this task required similar knowledge as its verbal counterpart, but was visual in structure.

Select the answer you feel best identifies the part of the heart indicated by the numbered arrows and mark the corresponding letter on the provided answer sheet. All responses should be made in pencil.

32. The inside lining of the heart wall:



33. The part(s) of the heart through which deoxygenated blood enters:

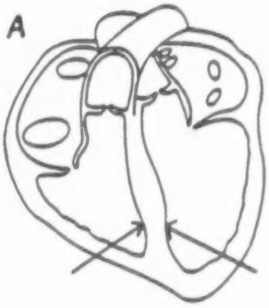


4) Complex Concept Task

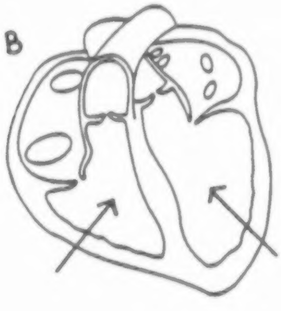
This task required the same knowledge of "if-then" relationships as its verbal counterpart, but was visual in structure.

44. **The part of the heart in which the contraction impulse starts:**

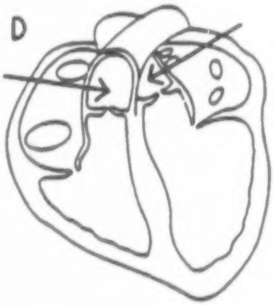
A



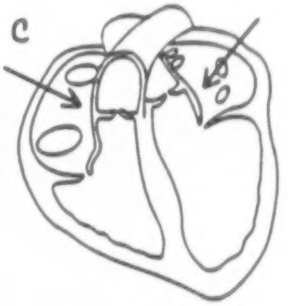
B



D



C



5) Problem Task Visual, Free Recall

The problem task visual free recall was considered the most difficult of the five tasks. The learner had to prepare from memory a line drawing of the heart with the parts indicated and in the correct location and labeled. Then the learner had to indicate blood flow through the heart pump system by drawing a series of dotted lines showing how the parts interact during heart operation, and then had to indicated the heart phases. Similar to the other learning tasks, there were 20 possible points on this task.

Procedures

There were 78 subjects participating in this study, having 13 subjects in each independent group. Subjects were undergraduates enrolled in College of Education at Ohio State University. Subjects were randomly assigned to one of the six independent groups in the study from a sign-up sheet.

On the day of the study subjects in each group were given a brief introduction about what they would be doing and then assigned to the computer center to work through the instructional programs. Subjects then went to a testing room, where they were given the five tests. Tests were given in an order so that cues were not given for other tests. Subjects were not aware that there were two basic types of testing, visual and verbal.

Data Analysis and Conclusions

Data collected have been analyzed using an analysis of variance procedure with repeated measures (ANOVR). Table 1 gives the summary results of the ANOVR. Table 2 provides the resulting main effect and simple effect means, with figure 2 providing a graph of the resulting significant interaction between MCBI, testing, and test difficulty.

This interaction indicated that subjects without the learning strategies, in the EP group did not perform as well on visual testing as on verbal testing. Additionally, the image cue strategy and attention directing strategy improved performance slightly on both visual and verbal testing. However, the EP no strategy group performed well on the verbal testing condition and slightly better than the strategy groups. There was a slight encoding specificity effect between visual and verbal testing with the EP no strategy group. Adding the program embedded strategies did slightly improve learning as was expected, but there are some cautions within the context of the present study.

It should be noted that this three way interaction is borderline statistically significant, at [.057]. This [.057] or [.06] value is not typically accepted as a statistically significant value. However, this study represents a preliminary study on visual and verbal testing with the three varied MCBI conditions. The small number of subjects in each independent cell of only 13, probably added to this result, and the other insignificant interactions. An additional problem with the experimental design is the use of an immediate testing condition. It is likely that the addition of a second within subjects variable of a one-week delayed testing condition would yield significant results on the main effects of MCBI type and visual versus verbal testing, along with significant interactions.

The hypotheses were not supported by these results probably because of the low number in each independent cell. Additionally, the one-week delay measure on testing could eliminate the effects of immediate memory and possibly yield significant results on both main effects and interactions. While the results were generally statistically insignificant the study should not be considered a complete loss. The experimenters were able to further refine the MCBI instructional programs, the visual testing condition, and found that program embedded strategies are beneficial. Additionally, the experimenters plan to repeat this study with an increased number of subjects in each indepdendent cell, and the addition of a one-week delayed testing variable. The next study will be a (3x2x5x2) ANOVR experimental design, with the same two between subject variables and two within subject variables, adding delayed testing.

While there is a good deal of pressure for researchers to produce significant results, it is necessary to conduct preliminary research to evaluate instructional and testing conditions, subject behavior, experimental designs, and experimental procedures. This situation is well known in the area of science, medicine, and engineering, where a line of inquiry may yield a series of studies with only minor refinements, eventually leading to significant results over the long run.

	External Paced MCBI (EP)		***EP MCBI & Image Cue Strategy (IC)***		***EP MCBI & Attention Cue Strategy (AC)***	
	Visual Testing	Verbal Testing	Visual Testing	Verbal Testing	Visual Testing	Verbal Testing
List Learning Task						
Cued Recall Task						
Simple Concept Task						
Complex Concept Task						
Problem Task						

FIGURE 1

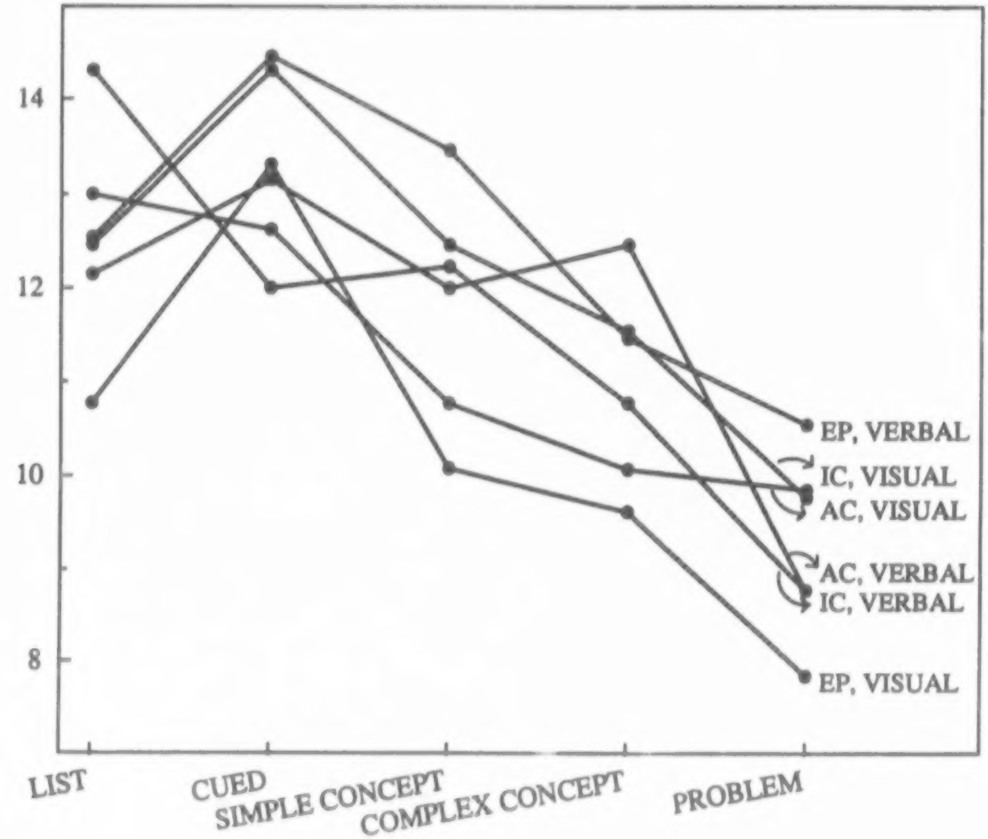

14
12
10
8
LIST
CUED
SIMPLE CONCEPT
COMPLEX CONCEPT
PROBLEM
EP, VERBAL
IC, VISUAL
AC, VISUAL
AC, VERBAL
IC, VERBAL
EP, VISUAL

FIGURE 2

ANOVR DATA

Source	*Mean Sq.*	*Df*	*f. Ratio*	*P*
Between				
MCBI (A)	7.699	2	.105	.90
Visual•Verbal (B)	48.831	1	.668	.42
A x B	59.223	2	.810	.45
Er.	73.101	72		
Within				
Test Level (J)	189.503	4	30.07	.002
A x J	7.246	8	1.15	.33
B x J	9.26	4	1.47	.21
A x B x J	12.095	8	1.92	.057
Er.	6.302	288		

TABLE 1

	External Paced MCBI (EP)		*EP MCBI & Image Cue Strategy (IC)*		*EP MCBI & Attention Cue Strategy (AC)*		
	Visual Testing	Verbal Testing	Visual Testing	Verbal Testing	Visual Testing	Verbal Testing	
List Learning Task	10.77	12.54	12.46	14.31	13.0	12.15	12.54
Cued Recall Task	13.31	14.46	14.31	12.0	12.62	13.15	13.31
Simple Concept Task	10.08	13.46	12.46	12.23	10.77	12.0	11.83
Complex Concept Task	9.62	11.46	11.54	10.77	10.07	12.46	10.99
Problem Task	7.84	10.54	9.77	8.77	9.85	8.77	9.26
	10.32	12.49	12.11	11.62	11.26	11.71	
	11.41		11.86		11.48		

TABLE 2

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Title:

Cognitive Science and Instructional Technology: Improvements in Higher Order Thinking Strategies

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Cognitive Science and Instructional Technology: Improvements in Higher Order Thinking Strategies

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Paper presented in the symposium, Improvements in Higher-Order Thinking Strategies: Research Findings from Cognitive Science, Mariana Rasch (Chair), at the annual meeting of the Association for Educational Communication and Technology, Dallas (February 1989).

Cognitive Science and Instructional Technology:
Improvements in Higher-Order Thinking Strategies

A recent national report on education concluded that society's future depends on a citizenry that can "think and reason creatively and deliberately; develop sound judgments of information (and) understand and contend effectively with rapid and constant change..." (National Commission, 1983). Likewise, a national teacher education task force urged the development of a curriculum "that emphasizes higher-order thinking strategies" (National Task Force, 1986). In other words, the purpose of education should include not only the acquisition of knowledge, but also the development and improvement of higher-order cognitive processes. Unfortunately, the achievement of these learning goals still elude educators even after decades of concern because of the serious lack of basic research on instructional strategies that can empirically demonstrate the improved learning of higher-order thinking strategies.

However, in the last decade developments in cognitive science have forged interdisciplinary approaches to learning and thinking such that we now seem to understand more about how and why people both acquire knowledge and employ it in the service of problem solving (Gagne & Glaser, 1987). These advancements, in what can be called cognitive learning theories (Tennyson & Christensen, 1988), offer a means to not only more fully understand learning and thinking processes but they also provide the means necessary for prescribing instructional strategies that can predictably improve these cognitive processes (Wertheimer, 1985).

Higher-order thinking involves cognitive processes directly associated with the employment of knowledge in the service of problem solving and creativity (Gagne, 1985). Basically, these processes enable the individual to "restructure" their knowledge by (a) analyzing a given situation, (b) working out a conceptualization of the situation, (c) defining specific goals for coping with the situation, and (d) establishing a possible solution (Breuer & Hajovy, 1987).

Complex problem simulations. The purpose of this paper is to present an instructional method that has been empirically shown to significantly improve higher-order thinking strategies (i.e., problem solving). The method employs computer-managed simulations that present contextually meaningful problem situations that require students to prepare solution proposals. The simulation assesses the proposal and offers the students the consequences of their decisions while also iteratively updating the situational conditions. This type of simulation, unlike conventional simulations which are used for the acquisition of knowledge, presents dynamic problems, requiring the students to fully employ their knowledge base by generating solutions to domain-specific problems (Bransford & Stein, 1984).

In this paper I will first elaborate on the cognitive processes associated with higher-order thinking strategies so as to more clearly define the prescribed instructional method to improve problem solving. Following that presentation, I will describe the instructional strategy and, finally, present software examples of the method.

Learning and Cognition

An important contribution of cognitive psychology in the past decade has been the development of theories and models to explain the processes of learning and cognition (Streufert, Streufert, & Denson, 1985). The value of these theories is that they offer operational definitions of not only how learning occurs but why it occurs. The why explanation provides more direct means for understanding how instructional strategies may accomplish predictable improvements in both learning and thinking.

Cognitive Model

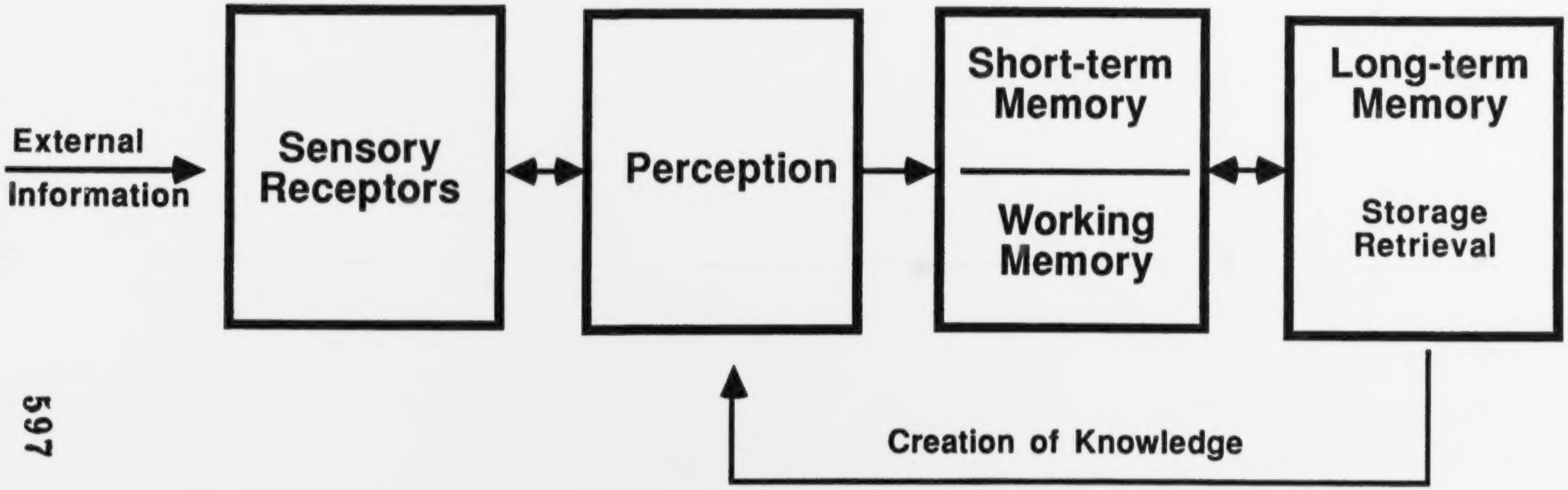
In this section I present an overview of a learning and cognition model to illustrate the relationship between the proposed instructional method and higher-order thinking strategies (Tennyson & Christensen, 1988). Figure 1 shows that the acquisition of knowledge comes from both external and internal sources. This is an important concept to the instructional issue of developing and improving higher-order thinking strategies because most cognitive theories assume these processes to be controlled by internal cognitive systems. That is, to operationally account for them, it is necessary to consider instructional strategies that include direct reference to internal cognitive systems as well as ones that always rely on learning as occurring from external sources only (Anderson, 1980, 1982). The basic components of our cognitive system model include the following: sensory receptors (i.e., eyes, ears, touch, etc.), perception, short-term and working-memory, and long-term memory (storage and retrieval).

Insert Figure 1 about here

Perception. Information coming from either external or internal sources passes through the perception component which performs the function of being aware of and assessing the potential value of the information for purposes of attention and effort in cognitive processing (Doerner, 1983).

Short-term and working memory. The next component consists of two forms of memory that only deal with immediate cognitive processes: short-term memory and working memory. Short-term memory is defined as having a limited capacity in which information is maintained only for the moment at hand (actually only a few seconds at maximum). Working memory on the other hand involves conscious effort or metacognitive awareness of the encoding process between itself and long-term memory (Brown, Armbruster, & Baker, 1984).

Long-term memory. The acquisition of information (learning) and the means to employ it (thinking) occurs within the storage and retrieval subsystems of the long-term memory component. The storage system is where new



External Information

Sensory Receptors

Perception

Short-term Memory

Working Memory

Long-term Memory

Storage Retrieval

Creation of Knowledge

Cognitive System

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information is learned and assimilated into the existing knowledge base. A knowledge base can be described as an associative network of concepts (or schemas) varying per individual according to amount, organization, and accessibility of its information (Rabinowitz & Glaser, 1985).

The retrieval system involves the twofold cognitive process of selecting and organizing knowledge for purposes associated with a given situation. That is, the former process differentiates knowledge in memory based upon criteria for selection, while the latter process integrates the knowledge for serving the given need (Schroder & Suedfeld, 1971). It is in the retrieval system that we are most concerned with when considering instructional strategies to improve higher-order thinking processes. In Figure 2, we illustrate the distinctions between the two sub-systems of long-term memory.

Insert Figure 2 about here

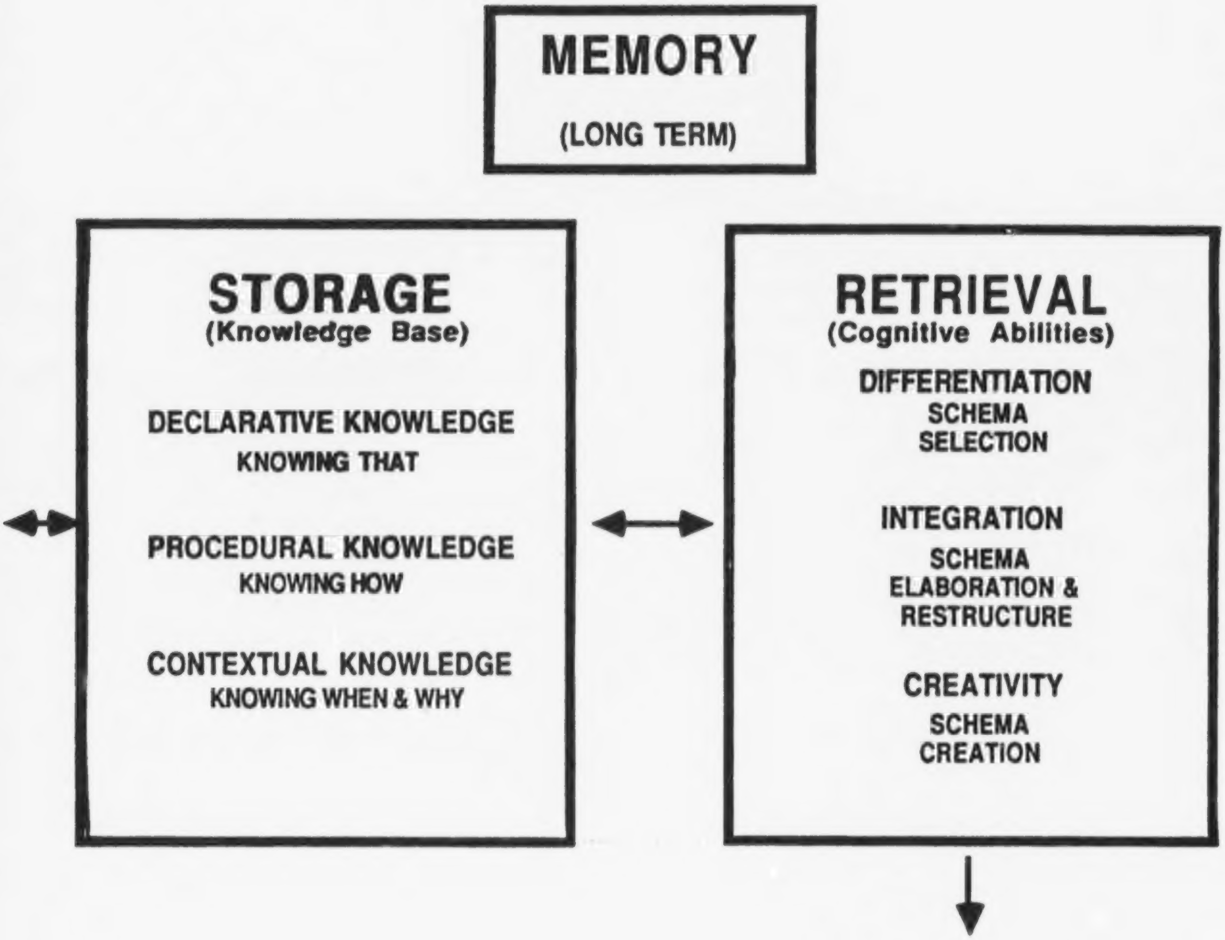
Within the storage system of memory there are various forms of knowledge: declarative, procedural, and contextual (Shiffrin & Dumais, 1981). Each form represents a different memory system or function. Declarative knowledge implies an understanding and awareness of information and refers to the "knowing that," for example, that underlining keywords in a text will help recall. Procedural knowledge implies a "knowing how" to employ concepts, rules, and principles in the service of given situations. Contextual knowledge implies an understanding of when and why to select specific concepts, rules, principles from the knowledge base. The selection process is governed by criteria (e.g., values and situational appropriateness). Whereas both declarative and procedural knowledge form the amount of information in a knowledge base, contextual knowledge forms its organization and accessibility.

The retrieval system of memory employs the knowledge base for the thinking strategies associated with recall, problem solving, and creativity (see Figure 2). Recall simply implies the automatic selecting of knowledge directly as stored in memory. Problem solving involves more complex thinking strategies that require both the cognitive processes of differentiation and integration (restructing) of information from the knowledge base. Creativity is the highest order of thinking because it implies the creating of knowledge as well as the employment of the cognitive processes of differentiation and integration.

Cognitive Complexity

Higher-order thinking involves three cognitive processes: differentiation, integration, and creation of knowledge. The first two processes occur primarily in the retrieval system of memory while the third further involves the other components of the entire cognitive system (see Figure 1).

The operational term for the retrieval system functions of differentiation and integration is cognitive complexity (Schroder, 1971). Cognitive



MEMORY

(LONG TERM)

STORAGE
(Knowledge Base)

DECLARATIVE KNOWLEDGE
KNOWING THAT

PROCEDURAL KNOWLEDGE
KNOWING HOW

CONTEXTUAL KNOWLEDGE
KNOWING WHEN & WHY

RETRIEVAL
(Cognitive Abilities)

DIFFERENTIATION
SCHEMA
SELECTION

INTEGRATION
SCHEMA
ELABORATION &
RESTRUCTURE

CREATIVITY
SCHEMA
CREATION

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complexity, as contrasted to intelligence (which seems to be more of a trait cognitive condition), is an ability that can be developed and improved with direct instructional intervention. Differentiation is defined as a twofold cognitive process as follows: (a) the ability to understand a given situation; and (b) the ability to apply appropriate criteria by which to select necessary knowledge from storage. Integration is the process of forming new schema(s) from selected knowledge. Creativity is the process to form new knowledge by employing the total cognitive system.

Criteria. An important aspect of the differentiation process is the concept of criteria. Criteria are the standards or values by which a judgment or decision of selection may be based. Criteria are an integral attribute of contextual knowledge (Paris, Cross, & Lipson, 1984). However, in higher-order thinking situations, criteria may have to be developed within the context of the integration and creation processes. Because many higher-order thinking situations do not necessarily exhibit right or wrong criteria for knowledge differentiation, values in terms of functional or moral reasoning need to be an integral part of such problem solving and creative situations.

Within the context of contemporary research in cognitive complexity, Kohlberg's (1981) theory of moral reasoning has been used to explain situational decision making (Streufert & Swezey, 1986). Kohlberg considers moral reasoning as an ability that can be developed and, as Hunt (1975) points out, should be learned concurrently with the acquisition of contextual knowledge. For my purposes here, we need to consider only Kohlberg's conventional and postconventional levels. Basically, the conventional level involves values associated with the general society, either in terms of culture and customs or laws and rules. The postconventional level focuses on individuals developing their own values in terms of ethical principles they choose to follow (Note. Stage 5, are standards usually agreed upon by society, while Stage 6, are self-chosen standards).

Intelligence

I have defined cognitive complexity as an ability that can be improved and, as such, is not necessarily correlated to intelligence (Simon, 1980). However, in a schooling environment, intelligence needs to be considered along with cognitive complexity so as to insure that the students are developing their full potential in all possible areas of knowledge (Flavell, 1977). That is, the more fully developed the knowledge base in memory, the greater the opportunities for differentiation and integration, and, possibly, creation of knowledge. Although the debate on theories of intelligence is beyond the scope of this article, I take a pragmatic view that there are a number of definable kinds of intelligence.

The contemporary work of Gardner (1984) updates the notion of multiple intelligences by identifying seven largely autonomous kinds of human intelligences. Each tends to have its own original location in the brain, each arises on its own schedule in the normal development of the brain and each functions uniquely. Gardner's seven intelligences are linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, perception of self, and sense of others. The first four form the intelligences which are most associated with cognitive processing, but the latter two are important for development of criterial values integral to differentiation.

The cognitive processes of differentiation, integration, and creation of knowledge are abilities that can be improved by effective instructional strategies. Intelligence, on the other hand, seems not to be directly influenced by instructional conditions: however, in curriculum planning, education should be concerned with the enhancement of all kinds of intelligences while prescribing instruction that improves both the acquisition of knowledge and the development of thinking strategies in problem solving and creativity.

Next I summarize how the cognitive complexity processes of differentiation and integration form conditions for thinking strategies. Within this summary, I will indicate how criteria and intelligence interact with the various conditions.

Conditions in the Development of Thinking Strategies

Thinking strategies represent a continuum of conditions ranging from a low-order of automatic recall of existing knowledge to a high-order of creative thought (see Figure 2). In Table 1, I summarize the three conditions associated with thinking strategies (i.e., recall, problem solving, and creativity) by their respective employment of the cognitive processes of differentiation, integration, and creation of knowledge. The conditions are further categorized by identifying situational characteristics and their respective criteria.

Insert Table 1 about here

Recall. The first thinking strategy, recall, represents the retrieval of knowledge from memory as it exists. This first condition is the most basic and automatic form of knowledge employment for the purpose of serving previously encountered situations. Situations represent problems that were either learned concurrently with the information or gained later through experience.

Recall strategies involve an automatic differentiation of knowlege from the existing knowledge base. The criteria for differentiation is an integral part of the contextual knowledge. For example, when a musician is asked to perform a familiar piece of music, the existing schema is retrieved from long-term memory and executed without modification. The cognitive process involved is the differentiation of the appropriate schema from others organized in the knowledge base.

A higher-order recall strategy is employed when more complex situations in which new conditions that have not been previously encountered are part of the

Table 1

Thinking Strategies: Recall, Problem Solving, and Creativity

Situation	Conditions	Criteria
	Recall	
Previously encountered	Differentiate from existing schemata	Part of schemata
Previously encountered/ new conditions	Differentiate and integrate from existing schemata	Part of schemata
	Problem Solving	
Previously unencountered	Differentiate and integrate to form new schema	Part of schemata
Previously unencountered	Create knowledge, differentiate, and integrate to form new schema	Develop new criteria
	Creativity	
Create	Differentiate and integrate to form new schema	Part of schemata
Create	Create knowledge, differentiate, and integrate to form new schema	Develop new criteria

problem. This cognitive process is still automatic for differentiation but given the new conditions, integration of knowledge from existing schemata must be done. This is the condition of cognitive processing that most experts operate at because of the sophistication of their knowledge base gained from experiences. Again, the criteria for differentiation is part of the existing contextual knowledge.

For example, when a musician is asked to perform a familiar piece of music under altered conditions (e.g., in a new key or a new arrangement) differentiation is not the only cognitive process needed. While the schema for the music is retrieved, the musician must also retrieve existing schema that deal with the new conditions (e.g., how to transpose from one key to another). The integration of all appropriate schemata is required to succeed at the task.

Problem solving. This condition is primarily associated with situations dealing with previously unencountered problems. That is, the term problem solving is most often defined for situations that require employing knowledge in the service of problems not already in storage. In these types of situations, the thinking strategies require the integration of knowledge to form new schema.

A first condition of problem solving involves the differentiation process of selecting knowledge that is currently in storage using known criteria. Concurrently, the selected knowledge is integrated to form a new schema. Cognitive complexity within this condition focuses on elaborating the existing knowledge base. For example, when learning an entirely new piece of music, a musician must create a new schema for the music in the retrieval system of long-term memory. This is accomplished by differentiating the known elements of all music that exist in the piece, and integrating them with new connections into a representation of the unfamiliar music. The new schema then becomes part of the knowledge base.

In contrast to the above problem situation, are those in which the current knowledge base is insufficient, requiring therefore the creation of knowledge by employing the entire cognitive system (see Figure 1). That is, given that the necessary knowledge to solve the problem is not in memory, new knowledge must be created by: (a) the internal processes of extending, elaborating, transferring, and forming new linkages; (b) the external process of acquiring information; or (c) a combination of the two. Concurrently, new criteria for the differentiation process must be developed. Obviously, with this condition, Kohlberg's first postconventional level would be most preferred for criteria development because of the concern for values with a social contract orientation. It is also at this stage that the Gardner's kinds of intelligences become important factors in solving the problem. Thus, the sophistication of a proposed solution is a factor of the person's knowledge base, level of cognitive complexity, higher-order thinking strategies, and intelligence.

For example, if a highly trained classical musician is asked to perform jazz, it may require the creation of new knowledge about jazz idioms. This new knowledge may be developed either by the internal three-way interaction of the musician's cognitive complexity, higher-order thinking strategies, and musical intelligence or by combining the three with external information sources (e.g., an expert in jazz). It will also require the development of new criteria for determining the quality of the performance based on criteria held by the jazz community.

Creativity. The highest order of human cognitive processing is the creating of the problem situation. Rather than having the external environment dictate the situation, the individual, internally, creates the need or problem.

Within one condition, the individual creates new situations but only within his/her own current knowledge base. Differentiation is done within the schemata and criteria available. Solution to the situation is done by integration of the selected knowledge in forming a new schema.

For example, composers often have a recognizable style in their music even though individual pieces are new and varied. That is, utilizing the existing knowledge base they create new music judging its quality against existing criteria.

The highest cognitive condition exists when the individual creates not only the situation, but also the new knowledge and criteria necessary for solution. Creating knowledge involves the entire cognitive system. Thus, in contrast to recall thinking strategies , which are characterized as the automatic functioning of the cognitive processes, creativity seems to involve both the conscientious deliberations of differentiation and integration and the spontaneous integrations that operate at a meta-cognition level of awareness.

For example, by developing or acquiring new compositional techniques, a composer may make an innovative change in style. That change may further require the development of new criteria corresponding to the new style. Differentiation and integration using the new criteria allows for the creation of new knowledge.

In the next section Iwill present an instructional strategy that has been empirically tested to develop and improve higher-order thinking processes (especially the cognitive processes of differentiation and integration). This work has been done within a program of research associated with the Minnesota Adaptive Instructional System (MAIS; Tennyson & Park, 1987).

Complex Problem Simulations

Simulation in educational computing is a widely employed technique to teach certain types of complex tasks (Breuer & Hajovy, 1987). The purpose for using simulations is to teach a task as a complete whole instead of in successive parts. For example, simulations are used in aviation training to replicate the complex interaction of a number of variables needed to successfully pilot an airplane. Learning the numerous variables simultaneously is necessary to fully understand the whole concept of flying. I define these types of simulations as problem-oriented because the educational objective is to learn the variables (i.e., declarative and procedural knowledge) and their context (i.e., contextual knowledge).

However, my concern in this paper is not with the acquisition of knowledge but the employment of knowledge in the service of problem solving. Thus, I am most concerned with simulations that will help students improve their cognitive complexity in problem solving; that is, cognitive processes associated with the retrieval system of memory rather than the storage system (see Figure 2). Whereas, problem-oriented simulations may improve the latter, complex problem simulations focus on the improvement of the former. The assumption in complex problem simulations is that the student has acquired sufficient knowledge to proceed in the development of thinking strategies employing the cognitive processes of differentiation and integration (and, perhaps in creating knowledge).

Because I am interested from an educational perspective in both the acquisition of knowledge and the improvement of cognitive abilities for problem solving, I have approached the design of an instructional strategy for enhancing higher-order thinking strategies development from a total curricular and instructional system (Seidel & Stolurow, 1980). That is, instead of viewing the learning of higher-order thinking strategies as being independent from other conditions of learning, I have made it an integral component of the Minnesota Adaptive Instructional System (MAIS). As with the other instructional variables and conditions of the MAIS, the complex problem simulation technique presented here can be applied in other instructional systems other than the MAIS. To illustrate the relationship of higher-order thinking strategies to knowledge acquisition, I will briefly review the MAIS.

MAIS environment. The MAIS is basically a computer-based research tool in which we have investigated instructional variables associated with improving learning according to individual differences and needs. As such, the instructional variables are represented in adaptive instructional strategies that in turn are monitored for each student by a expert tutor system using artificial intelligence techniques (Tennyson, 1987). Figure 3 illustrates the main components of the MAIS.

Insert Figure 3 about here

Briefly, the MAIS consists of two main components: (a) a curriculum component (or Macro), which maintains a student model (i.e., the cognitive, affective, and memory models of each student) and a curricular level knowledge base. An expert tutor system manages the Macro to maintain the student model and to select the appropriate information to be learned; and (b) an

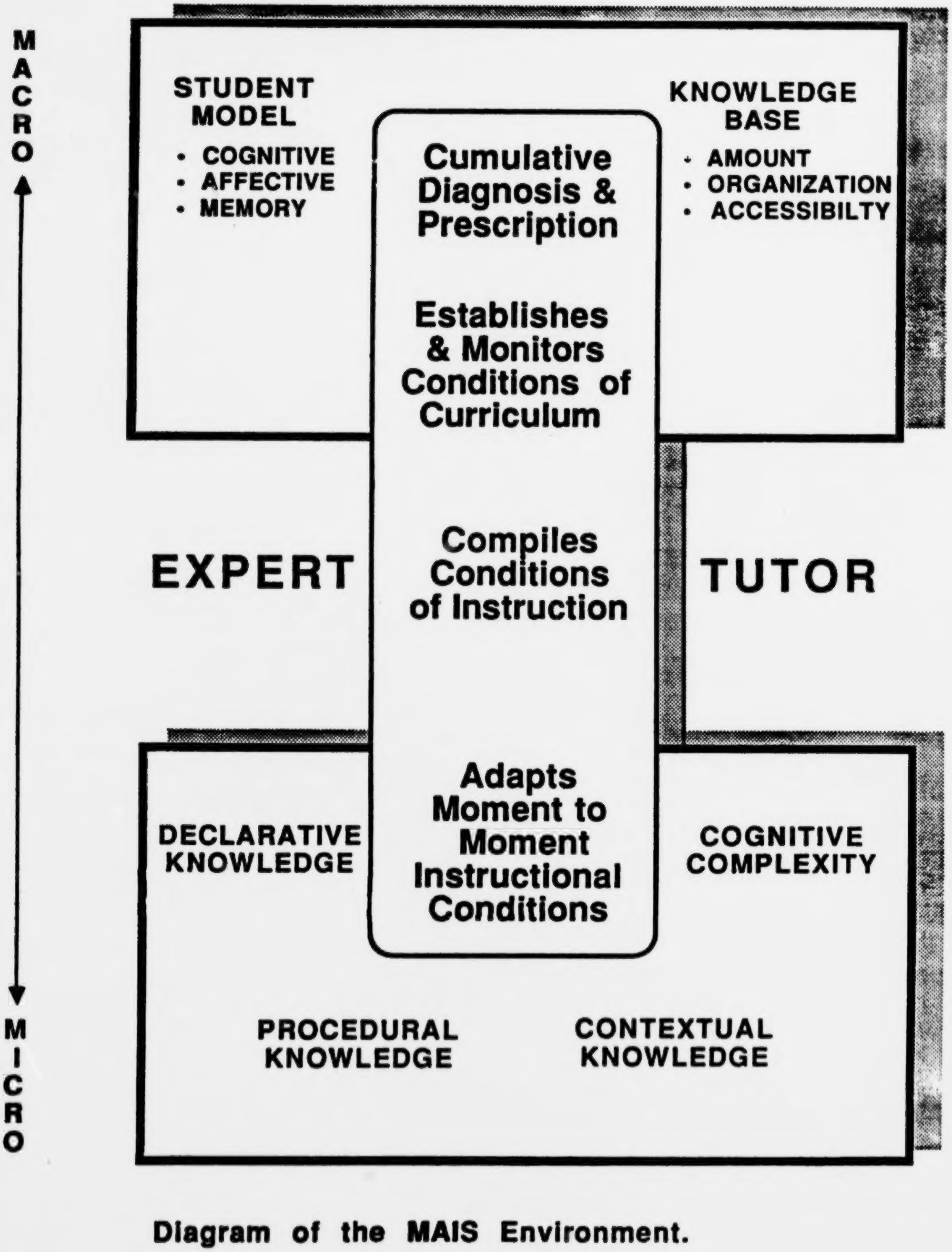
MACRO
MICRO
STUDENT MODEL
• COGNITIVE
• AFFECTIVE
• MEMORY
KNOWLEDGE BASE
• AMOUNT
• ORGANIZATION
• ACCESSIBILTY
Cumulative Diagnosis & Prescription
Establishes & Monitors Conditions of Curriculum
EXPERT
Compiles Conditions of Instruction
TUTOR
Adapts Moment to Moment Instructional Conditions
DECLARATIVE KNOWLEDGE
COGNITIVE COMPLEXITY
PROCEDURAL KNOWLEDGE
CONTEXTUAL KNOWLEDGE

Diagram of the MAIS Environment.

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instructional component (or Micro) that adapts the instructional strategies according to moment-to-moment learning progress and need.

The Micro is likewise managed by an expert tutor system that monitors each student's given learning need. The instructional strategies for the Micro are compiled based on the data from the Macro. As the student progresses through a given curriculum, the Macro data base is iteratively updated, which improves the refinement of the expert tutor decision making within each component.

The instructional strategies are compiled using Gagne's (1985) three conditions of learning: verbal information, intellectual skills, and cognitive strategies. The first two conditions represent the acquisition of knowledge (i.e., the storage system) while the third is associated with the learning of higher-order thinking strategies. Tennyson and Christensen (1988) present the instructional methods for acquisition of intellectual skills (i.e., the learning of declarative, procedural, and contextual knowledge), while in this paper I present the instructional strategy for the cognitive strategies condition of learning.

Simulation Design

The goal of our research in the area of higher-order thinking strategies is to investigate instructional variables that improve student employment of the cognitive processes of differentiation and integration. To accomplish this goal, we have tested instructional methods that have the following kinds of characteristics:

-Situations that themselves have a meaningful context (i.e., not a game) that require the students to use their own knowledge base;

-Complex situations to challenge the differentiation process;

-Exposes students to alternative solutions to improve their integration process;

-Students see challenging alternatives within each student's own level of cognitive complexity;

-Environmentally meaningful situations to develop values;

-Situations that use reflective evaluation rather than right or wrong answers to develop higher-order criteria;

-Situations that allow students to see consequences of their solutions and decisions;

-Situations that allow for predicting value of future states;

-Situations that allow for continuous development of higher-order thinking strategies.

Unlike conventional computer-based simulations, complex problem simulations do not necessarily employ the computer as the instructional delivery system. The main purpose of the computer in our design strategy is to manage (and, in the MAIS environment, to monitor) the simulation with the student doing most of the learning activities with resources other than the computer. Depending on the learning situation, the computer could certainly be used as a learning and instructional resource. For example, in flight training, the flight simulator could be used for the improvement of trainee higher-order thinking strategies following the design variables defined below. Most likely, this form of learning higher-order thinking strategies as contrasted to acquisition of knowledge would be a more effective use of flight simulators.

The design conditions of complex problem simulations are grouped under three main components: necessary knowledge, simulation, and learning environment.

Necessary knowledge. An important aspect in developing and improving higher-order thinking strategies is to make sure that the students have the necessary knowledge base to begin the complex problem simulation. Necessary knowledge includes the specific domain's declarative, procedural, and contextual knowledge. That is, it is within the student's own knowledge base that the student will perform the cognitive processes of differentiation and integration. Without the domain's necessary knowledge as prerequisite, the student will not be able to fully develop and/or improve their thinking strategies because there is no knowledge to differentiate and integrate. For example, in a system like LOGO which does not have a specifically defined domain of knowledge, students always come up with the same finite set of figures: usually coming from associated domains of knowledge.

Simulation. This design variable consists of two parts. The first establishes the problem situation while the second is the computer management system. The problem situation should include the characteristics listed above. In addition to those, the simulation should be longitudinal, allowing for increasing difficulty of the situation as well as providing the adding and dropping of variables and conditions. In more sophisticated simulations these alterations and changes should be done according to individual differences. Also, the kinds of intelligences should be considered within the curriculum plans.

The main functions of the computer-based management part of the simulation are: (a) to present the initial conditions of the situation; (b) to assess the student's proposed solution; and (c) to establish the next iteration of the conditions based on the cumulative efforts of the student.

Learning environment. To further enhance the development and improvement of higher-order thinking strategies, I am proposing the employment of cooperative learning methods. Current research findings on cooperative learning indicate significant improvement in the learning of information (i.e., storage system) when intra-group members help each other in goal attainment (for a complete review see Johnson & Johnson, 1987). Our own most recent research (Breuer, 1985, 1987) shows cooperative learning methods as improving problem solving strategies.

The research findings indicate that intra-group interactions in problem-solving situations contribute to cognitive complexity development because the students are confronted with the different interpretations of the given simulation conditions by the other group members. In this way new integrations between existing concepts within and between schemata can be established, alternative integrations to a given situation can be detected, and criteria for judging their validity can be developed.

An important issue in cooperative learning is the procedure used to group students. Most often, when cooperative learning groups are used for knowledge acquisition, the students are organized according to heterogeneous variables, such as gender, socio-economic, intelligence and achievement. However, our research shows that for development of thinking strategies, group membership should be on similarity of ability in cognitive complexity. That is, within groups, students should be confronted with solution proposals that are neither too much above or below their own levels of complexity.

For example, students with low cognitive complexity become frustrated and confused with highly sophisticated solutions, while students with high cognitive complexity are not only not challenged but become quickly bored with less sophisticated solutions.

The format of the group activity should employ a controversy method where a consensus is reached following a discussion of proposals independently developed and advocated by each member. This format is in contrast to the compliance method where a consensus is reached by members working together from the start.

The controversy method can be explained in the following steps:

1. The problem situation is presented to the students. The computer-based simulation prints out the initial conditions of the situation.
2. The students on an individual basis study the situation and prepare an independent proposal.
3. The students reassemble as a group to present their proposals. In the initial presentation, the students are to advocate their position.
4. Following the initial presentations, the students are to continue advocacy of their proposals in a debate fashion. The concept of the controversy method is used to help the students further elaborate their positions as well as seeing possible extensions and alternations.
5. The final goal of the group session is to prepare a cooperative proposal to input into the simulation. This consensus is reached only after a complete debate and should represent the group's "best" solution.

6. The computer program will then update the situation according to the variables and conditions of the simulation. The steps are then repeated until the completion of simulation.

In summary, complex problem simulations are designed to provide a learning environment in which students develop and improve higher-order thinking strategies by engaging in situations that require the employment of their knowledge base in the service of problem solving. In the final section I present examples of several of the simulations developed for our research and later converted to software products.

Software Examples

Complex problem simulations which were developed in Germany and the United States include the following:

- -The economic system of a municipality which is to be improved by the "town council."
- -The microeconomic system of a company which is to be run by a "manager."
- -The flood control-system within a county which is to be operated by an "executive."
- -The living conditions of an African tribe which should be improved by an "advisor."
- -The efficiency of fuel and energy consumption to meet modern-day needs.

In each of these situations, a set of materials were prepared in which the necessary knowledge was presented. The students were taught the information by both teacher presentations and print materials. After all students had learned the necessary knowledge they were assigned to a group based on similarity of cognitive complexity.

Each of the simulations represented dynamic situations. That is, they depicted situations that, without actions from the decision-makers, would collapse after a certain time period. For example, the tribe vanishes because of starvation, the company goes into the red, and so forth. Each of the simulations stressed the need for decision-making and the proposals required solutions that included cognitive conflicts.

The simulations were complex and longitudinal so that after each period of decision-making, the new status of the situation was reported to the students. This allowed the students to test the adequacy of their most current conceptualizations of the situation with the updated conditions, and usually resulted in the need for revisions. In addition, because of the open definitions of the situations in terms of global goals, the level of thinking remained high, preventing the mere recall of information.

In summary, the complex problem simulations which we have developed have shown significant improvements in the development of higher-order thinking strategies. That is, there were measurable increases in the cognitive processes of differentiation and integration.

Conclusion

The learning principle underlining our research program is that thinking strategies are acquired in reference to employment of the learner's own knowledge base and that they are not independent thinking skills. Our instructional principle is that, because cognitive complexity is an ability, it can be developed and improved with instructional intervention. Therefore, the goal of our research program is to study instructional variables within the context of an instructional system that takes into account both the storage and retrieval systems of long-term memory. The MAIS environment provides this opportunity because of direct concern for both curriculum and instruction and for all conditions of learning.

As this paper indicates, complex problem simulations focus on the improvement and development of higher-order thinking strategies (i.e., problem solving within the context of employing the knowledge base). We are continuing research at this level while future efforts will also include direct investigations at the creativity level. We anticipate that learning activities at that highest level will be more directed towards increased individual efforts with group activities geared more at critical analysis than consensus.

The influence of intelligence in the entire process of higher-order thinking is another problem area for our future research. We anticipate a high correlation between cognitive ability and intelligence, but perhaps will see other variables interacting in the cognitive process: such as criteria and values development and achievement motivation. Psychologist have long recognized that higher-order thinking strategies involve more than just acquisition of cognitive skills, but other variables and conditions of the total human system.

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Title:

Educational Research and Theory Perspectives on Intelligent Computer-Assisted Instruction

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Educational Research and Theory Perspectives on Intelligent Computer-Assisted Instruction

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Conventional intelligent computer-assisted instructional systems (ICAI) have a theoretical foundation which is based in computer science (Dreyfus & Dreyfus, 1986). Current ICAI programs are basically prototype systems whose aim is to enhance instruction through the employment of computer-based software tools. Most of these tools are directly associated with the expert systems methods of the artificial intelligence (AI) field. Given the computer science focus of these conventional ICAI programs, the attention given to learning and instructional theories has been minimal. As such, there is no direct empirical verification to show how the specific software tools may result in improved learning. The assumption of the conventional ICAI proponents is that the tools themselves will improve learning. However, learning and instruction are much more complex processes than are exhibited in the prototype ICAI systems and, when viewed from an educational perspective, these systems have a rather novice approach to both learning and instruction (Tennyson & Park, 1987).

With this perspective in mind, we would like to suggest that the next generation of ICAI will differ from the current software tool-based models, to instructional systems that have their theoretical foundations in educational and psychological theories of learning and instruction. The aim of the educationally-based ICAI systems will be to improve the acquisition, storage, and connections between instructional variables and learning. The next generation ICAI systems will employ the AI/expert systems tools but with variables and conditions directly related to the fields of psychology and education. This paper will define the next generation of ICAI by showing the elaborations and extensions offered by educational research and theory perspectives to enhance the ICAI environment.

Conventional ICAI

Conventional ICAI systems, using expert systems methods, have three major modules (or models) (Fletcher, 1984); a knowledge base, a student model, and a tutor model. Each of these modules can be summarized as follows (Figure 1):

- Knowledge base. A data base which represents knowledge of a specific topic that an expert may have in memory. The information in a knowledge base is usually obtained by an interview conducted between an individual labelled as a knowledge engineer and a subject matter expert. The goal of this process is to query the expert so as to obtain both declarative knowledge and procedural knowledge. The idea is to have a knowledge base module that can both generate solutions to previously unencountered situations and make inferences from incomplete measures or data.

-Student Model. A mechanism for assessing the student's current knowledge state of the information in the knowledge base. The student's prior knowledge state is generally represented as either a subset of an expert's knowledge (e.g., overlay model, Goldstein, 1982) or the student's misconceptions of the expert's knowledge base (e.g., the buggy model, Brown & Burton, 1978).

-Tutor Model. The purpose of this module is to manage the instruction. This is done by a management system (termed an inference engine) that makes decisions such as selecting problems to be solved, critiquing performances, providing assistance upon request, and selecting remedial materials.

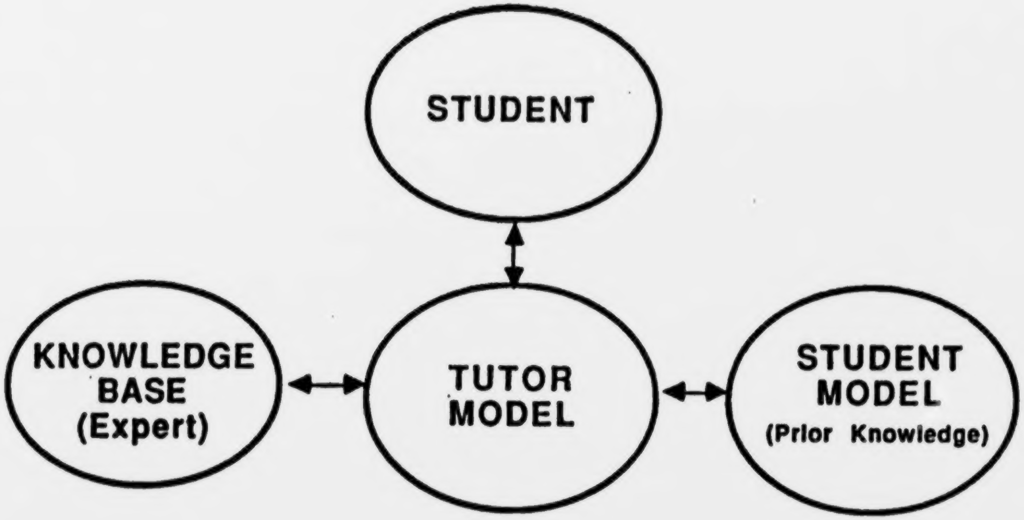
In conventional form, the tutor model employs basically a single instructional strategy embedded in the system for all students and situations. For example, the most commonly used strategy is a Socratic method of teaching which requires the student to response to a given stimulus. As such, the strategy borrows heavily from the early programmed instruction (PI) format of intrinsic programming developed by Crowder in the late 1950s.

Insert Figure 1 about here

Educational Research and Theory Perspectives

Because of the powerful programming tools offered by the developments in AI software intelligence methods, we feel that computers can now offer educators a means to more fully utilize the capabilities of the computer to enhance instruction and, thus, improve learning. To fully accomplish this goal, the AI tools need to be employed within the conditions of the educational environment. Proposed for the next generation of ICAI, is a system that elaborates and extends the three basic modules of the conventional ICAI system (see Figure 1). The proposed additions are taken directly from a rich base of cognitive psychological and educational theory and research on learning and instruction. The educational perspective offers ICAI, in contrast to the contemporary computer science

Conventional ICAI Components


STUDENT
KNOWLEDGE BASE (Expert)
TUTOR MODEL
STUDENT MODEL (Prior Knowledge)

Educational Elaborations

- Developmental Knowledge
- Different Perspectives
- Creative Search Strategies
- Informal Heuristics
- Meta-Learning Theory
- Meta-Instructional Strategies
- Individual Differences
- Necessary Knowledge
    - Prerequisite
    - Associative
    - Background

Elaborations to ICAI from an Educational Perspective.

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perspective with its limited and narrow understanding of learning and instruction, an integration of AI tools and methods with instructional variables and conditions empirically tested and shown to improve learning. The basic educational elaborations and extensions can be summarized as follows (see Figure 1):

- To extend the knowledge base to include, in addition to the expert's knowledge, developmental knowledge used by the learner to acquire expert knowledge (i.e., Dreyfus & Dreyfus, 1986).

- Develop knowledge bases in ways that represent different perspectives on problem solving and problem formation.

- Employ inference engines within tutor models that use informal and fuzzy logic methods in addition to the structured formality offered by the current methods of IF THEN rule statements. This would allow for much broader applications of ICAI in less structured domains of information (e.g., the humanities).

- Extend the forms of knowledge representation to include, in addition to the usual tree structures, heuristic systems that create search strategies.

- Design tutor models that more fully exhibit the characteristics of an expert teacher by increasing the potential of the instructional strategy. That is, a tutor model that prescribes, instead of a given single strategy, a meta-instructional strategy formed from a rich pool of instructional variables.

- Expand the student diagnosis to include individual differences. Rather than the simple assessment of prior knowledge to prescribe instruction, additionally evaluate students in reference to cognitive and affective variables.

- Elaborate the student model by assessing in addition to prior knowledge other forms of necessary knowledge. These other forms include: (a) prerequisite knowledge, information directly needed to understand the information to be learned; (b) associative knowledge, information within the domain being learned but not directly connected or linked to the information being learned; and (c) background knowledge, information that provides a context to fully understanding the information to be learned.

In planning a learning environment, it is convenient to consider the division of the educational variables and conditions into curricular and instructional components (Tennyson &

Christensen, 1988). The curricular component includes those elements of education not directly linked to student interaction. The instructional component on the other hand deals with those elements directly involved with student interaction in learning. Using this paradigm, we will discuss the above defined educational elaborations for ICAI within these two components. Our assumption is that in an ICAI environment, these two components would operate in an iterative fashion such that the conditions of instruction established in the curricular component would adjust according to learner progress and needs while in the instructional component. And that learner outcomes from the instructional component would feed back to the curricular component to update the decision making mechanism at that macro level (Seidel & Stolurow, 1980).

Thus, in addition to the above defined elaborations, we propose that ICAI be extended into an educationally-based learning environment that includes both curricular and instructional variables and conditions. Also, that the ICAI system provide for adaptive instruction based on cummulative knowledge and moment-to-moment learning need. Within a curricular component, the system would diagnose the student from initial assessment information and then from continuous information coming back from the instructional component. The curricular component would prescribe the necessary instruction from normative parameters, while with the instructional component, the system would adapt the prescription according to individual student needs during actual learning. In this sense, assessment and learning would be occurring simultaneously. The next two sections will describe my proposed extension of the current ICAI model to more fully meet the educational situation as contrasted to the tool design paradigm offered by conventional ICAI.

Curricular component. The primary purpose of the curricular component would be to establish the initial conditions of instruction by considering the interaction of individual difference variables with the specifications of the content domain of a given curriculum. Conventional ICAI has no methodology which can deal with the considerable effect which individual differences have on learning achievement. The curricular component would encompass both the cognitive and affective measures of individual differences.

Cognitive measures would include such constructs as intelligence, aptitude, ability, and cognitive style. For example, a learner may have a high intelligence level but little aptitude or ability for a given curriculum. Thus, to maximize learning, instruction should be adjusted to take the learner's strengths and weaknesses in these areas into account.

Affective measures would deal with constructs such as (a) personality (e.g., introverted and extroverted learners need different optimal learning environments [Eysenck & Eysenck, 1975]; learners with a Type A personality tend to differ in drive from Type B [Friedman & Rosenman, 1974]); (b) motivation (a profile of the learner's initial motivation can be adjusted and have influence as the learner moves through the curriculum [Tennyson & Breuer, 1984]); and, (c) anxiety (instructional strategies can be employed to lessen anxiety where it interferes with learning [Tennyson & Boutwell, 1973]).

In conventional ICAI programs the student model is basically represented as a subset of an expert's knowledge base. This error model focuses on the student's prior knowledge and the ability for information recall, while ignoring the acquisition of the information. In this conventional ICAI model, learners can easily form misconceptions (even though such programs are actually trying to correct misconceptions), particularly in higher order and more complex information structures (Scandura, 1984).

The educational perspective offers to improve on this conventional student model by expanding it to include, in addition to prior knowledge assessment, achievement measures on three other types of necessary knowledge: prerequisite, associative, and background knowledge (Tennyson & Cocchiarella, 1986). Prerequisite knowledge refers to supportive knowledge that is (a) directly related to the information to be learned and (b) the student already has in memory. Associative knowledge refers to information that is in the same domain but is only indirectly connected with the to-be-learned information. Background knowledge refers to information that is generally outside the domain but provides necessary context for fully understanding the information to be learned. Prior knowledge, in contrast, refers to that specific information to be learned that the student already has in memory.

The addition of these other three knowledge achievement measures would influence the conditions of instruction in terms of remediation and the amount of instruction for the to-be-learned information. They would also establish a richer learner diagnostic profile for instructional prescriptions than one based solely on a single variable of prior knowledge as in the case of conventional ICAI.

Each of the above mentioned individual difference variables has differing effects on learning and needs constant adjustment based on the structure of the to-be-learned information. While each of these constructs has implications at the instructional level, because of their trait nature, putting them at the curricular level can definitely expand the capabilities of the conventional knowledge base (expert module) to better deal with the structural conditions of the information to be learned. In other words, curriculum issues can be dealt with in such a way that if learners found that they are either lacking or unsure of specific knowledge, that the system would be able to diagnose the specific knowledge lack and to appropriately adjust the curriculum.

Instructional component. The tutor module in conventional ICAI is basically limited to one instructional strategy; for example, the Socratic and coaching methods. With only one instructional strategy, the system can run into a number of limitations such as: assuming too much or too little student knowledge, producing instructional material at the wrong level of detail, and not being able to work with the student's own conceptualizations of the information which they are learning.

An educationally-based ICAI system would expand the tutor module by not limiting itself to only one instructional strategy. By assessing individual difference variables and curricular issues during instruction, the system can have the flexibility to prescribe appropriate integrated-instructional strategies (Tennyson, 1988).

This flexibility would be allowed by the use of informal heuristic methods in the inference engine of the tutor model. The use of these heuristic methods is built around a direct connection to cognitive science theories of learning (Ploya, 1945). A heuristic can be defined as a "rule of thumb" search strategy that is composed of variables that can be manipulated to provide increasingly better decisions as more knowledge is acquired. This ability allows the heuristics to adjust to new data and experiences and to add new variables and even heuristics without necessarily influencing the operations of the system.

Frequently, program designers refer to informal heuristics as "fuzzy " logic statements because, unlike the production rule statements needed in conventional ICAI programs (i.e., IF THEN statements), informal heuristics can be written as abstract flexible statements which acquire assumptions with experience. Therefore, an informal heuristic can start to understand a situation and "think" about possible outcomes that do not exhibit correct or incorrect solutions. Also, informal heuristic methods differ dramatically from the algorithm or tree-structure methodology of AI programming in that they are usually written as conditional probability statement codes. In educational terms, an informal heuristic may be thought of as a higher order rule statement rather than a depository of domain-specific information

(Dorner, 1983).

We propose the employment of the informal heuristic approach because the flexibility offered by such programming techniques allows the integration of various theory-based learning variables to a given programmatic method (e.g., few learning variables fit a tree-structure format). These heuristics would be used in the sense of leading to discovery by considering many different learning variables, abstraction levels (shifts from one level to another), and unique combination which establish the conditions for learning and the conditions of instruction.

Selection of the integrated-instructional strategies would be based upon four different sources of information (Tennyson & Rasch, 1988). First, the direct connection to a learning theory which explains learning, memory, and cognition. Typically, from an educational perspective, this would be in the form a meta-learning theory developed because of the educational need to explain both learning and cognition. Second, an understanding of the learning outcomes related to the objectives of the curriculum and instruction. Although, there are many taxonomies by which to specify learning objectives, we employ the well-developed approach offered by Gagne's (1985) conditions of learning (verbal information, intellectual skills, and cognitive strategies). Third, the structure of the information to be learned needs to be analyzed for both learning effectiveness and storage in the data base. Conventional expert system tools and shells provide assistance in the latter development of the knowledge base. However, the presentation structure needs additional manipulation to improve learning. Much of the recent research findings in human knowledge representation (as constrasted to machine representation as in AI/expert systems programs) clearly indicates that the overt structure of the information directly affects learner acquisition. That is, presenting the information in reference to its schematic structure significantly improves acquisition because the learner is storing both semantic knowledge and schematic knowledge simultaneously. Conventional ICAI knowledge base structures are only focusing on semantic understanding. And, fourth, the instructional variables which can be prescribed into specific and adaptable integrated-instructional strategies. Most of these instructional variables are derived directly from educational research findings. For example, some of these variables that can be prescribed based on individual student need and progess are sequence, amount of information, instructional control, time on task, use of text and visuals, cooperative learning, simulations, and others that an expert teacher may employ to facilitate learning.

Summary

In summary, the next generation of ICAI will differ from conventional ICAI on several important variables. First, with foundations in learning and instructional theory, ICAI wll use a comprehensive meta-learning model which would take individual differences into account in the assessment and diagnosis processes, and make reference to both the learner's acquisition (i.e. storage) and the retrieval of knowledge. Conventional ICAI programs follow, for the most part (if any), learning models based on the assumptions of a discovery form of learning. Second, ICAI will make no assumption for a given strategy of instruction; rather, the strategies of instruction will be selected from a rich base of instructional variables according to learning objectives and the structure of information to be learned. Third, ICAI will employ the concepts of artificial intelligence in the form of informal heuristics (as well as formal heuristics) that have the capacity to learn and, therefore, to adjust according to given situations.

The proposed educationally-based ICAI systems can be characterized as decision-making systems that are iterative in nature such that with experience, they can continuously improve the learning of each learner. This would be done by an adaptive management system which concurrently diagnoses learning while prescribing instruction. By monitoring learner progress during the actual acquisition of information, the educationally-based system will improve learning in terms of both the effectiveness of amount and quality of knowledge acquired and the efficiency in time required to learn.

At both the curricular and the instructional levels, the variables defined in this paper would interact in an almost infinite number of instructional conditions and events. Of special note will be the ability of the entire system to adjust decision making parameters both with group experience and by individual learner experiences. That is, as experience is gained from both sources, the heuristics which are formed with currently available information and data, would adjust accordingly. Because the heuristics would be independent of both hardware and software conditions, they would be easily transferred and generalized to other systems as well as accomodating new development in both hardware and software.

A number of major advantages can be implied by the use of the proposed educational elaborations and extensions of the current generation ICAI systems. For example, the next generation ICAI systems would be designed to improve learning by integrating learning theory with instructional design. Also, the systems would employ a holistic approach of pre-information and continuing information processing about the learner, rather than diagnosing and remediating specific problems as seen in conventional AI programs. Furthermore, the systems would be active rather than passive in nature, and would be able to recognize the totality of the individual and the complexities involved in creating favorable learning environments to improve learning.

In conclusion, we are proposing that the next generation of ICAI be based on educational and psychological theory and research findings. That it employ where appropriate the tools and shells of AI and expert systems methods, but that such tools do not dictate or control the design and implementation of the learning environment. Much like educators have for decades used the research tools from the field of statistics for help in experimentation, we can use the tools offered by computer science in the design of learning enviornments. In both situations, however, the educator most control the tools as a means to the end, not as the end in themselves as in the current prototype applications of ICAI.

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Title:

Alphanumeric and Graphic Facilitation Effects: Instructional Strategies to Improve Intentional Learning Outcomes

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Alphanumeric and graphic facilitation effects: Instructional strategies to improve intentional learning outcomes

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Running Head: INTENTIONAL LEARNING FACILITATION

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Abstract

Two assessment endeavors were undertaken to determine the relative impact of alphanumeric and graphic instructional mediators upon intentional and incidental learning outcomes in applied instructional contexts. The intent of these investigations was to determine the feasibility of embedding strategic organizational cues within instruction to improve intentional learning outcomes in contexts where direct interactive feedback opportunities are limited. Results indicated that alphanumeric and graphic displays both provided organizational frameworks for subjects to use in immediate recall exercises, and that facilitation effects for alphanumeric and graphic displays were not maintained in delayed recall exercises.

Introduction

Determination of the impacts of media upon learning has been an issue of considerable activity and the focus of much debate among American educational researchers. During the sixty-plus years in which such studies have been undertaken it has become clear that comparative media studies have not been able to offer clear evidence of superiority of one medium over another with regard to learning facilitation (Clark, 1983). As more and more technologies of instruction have become increasingly available for use in instructional contexts, it is increasingly less clear that there is value in identifying a hypothetically "best medium". Even as the interest in selecting an optimal medium has shifted from a product driven perspective to one which is more process driven (Wagner, 1986), interest in assessing message design efficacy for applications across media continue to grow. There appears to be a shift toward developing strategies to improve the efficiency with which instructional messages are designed so that their delivery via appropriately selected media (that is, media selected by virtue of their appropriateness for the learning/teaching task at hand) is facilitated.

Even so, the recent resurgence of interest in distance education (Moore, 1988) may have inadvertently contributed to renewed attempts to discover a "best medium" for use in distance educational endeavors. The contemporary distance educator's interest lies in developing instructional delivery systems making use interactive audio teleconferencing, audiographic teleconferencing, interactive compressed video teleconferencing, full motion video teleconferencing and interactive and asynchronous computer teleconferences to transmit "data, video and voice" in single through multi-modal delivery systems carried via satellite, coaxial cable or fiber optics. A resurgent interest in trying to identify the best medium for distance delivery applications has provided investigators with new opportunities to consider instructional delivery / instructional mediation strategies. Perhaps distance educational applications of "high tech" instructional delivery systems are to serve as a reminder that while the media carrying instructional messages may demand attention by virtue of their technological complexity, their complexity does not necessarily correlate with instructional efficiency. By focusing upon the selection and utilization of technologies of instructional delivery as the means through which instructional messages are to be transmitted, it becomes easier to focus upon instructional message design and development as a primary arena of endeavor. In order to accommodate the rapidity with which technological delivery systems are rendered obsolete, the emphasis of strategy-based investigations need to focus upon the characteristics and functions of the instructional messages being carried by means of targeted media, rather than considering simply the transmission efficacy of the media themselves. In taking this approach, generalizable strategies generated for use across a wide variety of instructional delivery systems may be more likely to emerge.

Discriminating the Critical from the Incidental

The ability of a novice learner to extract critical information provided by an expert in instructional situations may be hampered by the novice's inability to discriminate between those bits of information which are critical for developing a conceptual framework and those bits of information which are incidentally related to the learning task at hand. In situations where opportunities for direct interaction between expert and novice are limited, (e.g. large lecture hall instruction, teleconferenced instruction) learning to discriminate between critical and incidental information may be further hampered.

Merrill & Tennyson (1977) determined that the presentation form of information clearly affected the form of knowledge encoded in memory. Merrill's Component Display Theory (1983) proposed that secondary presentation forms can be embedded in a sequence of instruction to aid learning. Specifically, the descriptive part of the theory provided a performance content matrix for classifying instructional outcomes and primary and secondary presentation forms for describing presentation displays. The prescriptive parts of the theory provided consistency rules which suggested that learning, resulting from instruction, is most efficient and effective if combinations of primary and secondary forms are used to promote classes of performance/content outcomes (Merrill, 1987, p. 19).

Design considerations focused toward the facilitation of concept acquisition have included concerns for instructional strategies (i.e. expository, interrogatory methods of information presentation) as well as organizational and aesthetic presentation considerations. Tennyson & Cocchiarella (1986) have suggested that concept teaching can facilitate the instructional design process through the employment of instructional strategies aimed at effective formation of concept knowledge and corresponding procedural skills. Gagne's (1985) learning hierarchy states that the ability to discriminate presupposes the ability to acquire concepts; from an applied perspective, the ability to categorize and classify attributes to form concepts clearly assumes the ability to select intentional attributes from non-intentional attributes.

Use of visual display categories to facilitate concept acquisition has been included among the example/non-example design variables considered in empirical investigations. McLean, Yeh & Reigeluth (1983) found that a visual-only format was superior to either a verbal format or a visual-verbal combination when teaching conceptual relationships to high school students. McLean et al were concerned with assessing the strategic, organizational impact of visual and verbal presentation forms upon immediate and delayed recall tasks. The utilization of secondary presentation forms in conjunction with a large lecture and teleconferenced presentations appear to be similar in intent and focus to the McLean et al study. Both the present study and the McLean et al study appear to provide a basis for establishing an organizational framework through which investigations to determine instructional efficacy of embedded secondary presentation forms may be undertaken.

Research describing message transmission/reception effects of prose and pictorial stimuli may also have direct applicability upon graphic and alphanumeric recall facilitation effects for instructional applications . Anglin (1987) has suggested that there is ample evidence to support the notion that pictures can be used to facilitate the recall of information presented in prose passages. Much of Anglin's work has been based upon Levin's (1981) theoretical framework describing functional attributes of prose-relevant pictures. Levin (1981) proposed a framework to represent seven distinct functions to be served by prose-relevant pictures. This framework included the categories of: decoration; remuneration; motivation; reiteration; representation; organization; interpretation; and transformation. Anglin (1987) proposed that the function of a representational picture is to make the information contained in a prose passage more concrete; Levin (1981) had previously suggested that representational pictures would have a moderate learning facilitation effect, while transformational pictures would make the information in a prose passage more memorable.

Even before Levin and others began looking at picture function in prose applications, researcher have investigated the impact of verbal and pictorial/imaginal systems upon memory processes. Paivio (1969) asserted that images and verbal processes function as effective alternate memory coding systems because they are closely linked to experience with concrete objects, events and language. He proposed a two-process Theory of Meaning and Mediation which suggested that there are two distinct modes of information represented in memory: a verbal mode and a visual mode. While Paivio's interest in imagery stressed imagery as informational representation in memory, his investigations provided a foundation upon which examinations of the information transmission potentials of pictures could be structured. Nelson, Reed & Walling (1976) found that memory for pictorial stimuli generally exceeded memory for their concrete labels because pictures were more likely to be encoded as both imaginal and verbal codes. They also indicated that pictorial image codes may be qualitatively superior to verbal codes when dealing with simple pictures. Pellegrino et al (1976) indicated that picture retention was superior to word retention for long-term memory, suggesting that " a dual coding position maintains that there is a separate visual and acoustic representation for the picture stimuli and only an acoustic representation for the word stimuli." (p. 535)

The purpose of the present studies was to determine the facilitative impact of alphanumeric and graphic symbols upon recall of intentional and incidental information presented in a variety of instructional contexts. Additionally, it attempted to investigate possible contributions of alphanumeric and graphic symbols upon the reiterative and organizational functions in instructional applications. The symbolic representational systems employed in this study function directly as secondary presentation forms (Merrill, 1983); they bear a passing resemblance to Levin's (1981) prose-relevant picture functions, and may also function as cues as described by Beck (1984). The organizational strategy and delivery strategy variables described by Reigeluth & Merrill (1979) may provide a better conceptual framework for classifying the instructional variables underlying this discussion. Nevertheless, the determination of similarities between Levin's functional framework and Merrill's secondary presentation forms may ultimately provide some guidance for selecting appropriate presentation forms to elicit specific instructional outcomes.

The studies described herein took place in a large lecture instructional context and a simulated enhanced audio teleconference context. Materials employed in both contexts remained constant; assessment of immediate and delayed recall efficacy of intentional and incidental items also remained context. Specific questions to be answered as a consequence of these investigations included:

- Would the use of alphanumeric and graphic symbols in conjunction with a (taped)lecture improve subjects performance on a recall exercise?
- Would the means of transmission of the alphanumeric and graphic symbols impact performance efficacy?
- Would recall of intentionally reiterated information be facilitated over time as a consequence of exposure to either alphanumeric or graphic symbols during the encoding process?

Method - Study 1

Subjects

138 (23 male, 115 female) subjects were recruited from an educational technology course for pre-service teachers. Subjects were provided with extra course credit for their participation in the experimental exercise if they completed both the initial recall assessment and the delayed recall assessment one week later.

Design

A 2 x 3 design was employed. Immediate and delayed recall was compared across graphic, alphanumeric and control groups. General recall, recall of intentional items and recall of incidental items were compared. ANOVAs were performed to determine significant differences among means scores per recall exercise per experimental conditions.

Materials

A lecture describing a hypothetical communications holding company was developed to to control for prior knowledge effects. An elaborative structure was used in the presentation of conceptual information about the company and its related subsidiaries, while information about each company was presented in an expository manner. The 7 minute, 21 second lecture was recorded on audiotape and dubbed to three separate cassette tapes to provide for identical content and information presentation in the various treatment sessions. Two sets of four overhead transparencies each were prepared to accompany the taped lecture. One set displayed line drawings in which spatial relationships described in the tape were emphasized; the other set displayed lists of alphanumeric descriptors reiterating verbal information transmitted on the tape, which presented equivalent information to that which was displayed in the graphic transparencies. Two equivalent recall tests of 24 items each were developed, one for use immediately the control / treatment conditions (Test #1) and for a one-week delayed test (Test #2). The recall tests included 10 items dealing with information included on the verbal and graphic transparencies; these were coded as intentional recall items. The recall tests also included 10 items dealing with information which was mentioned on the audiotaped lecture, but were not visually presented either in graphic or verbal presentation modes; these were coded as incidental recall items. A demographic assessment instrument was employed to obtain descriptive information about each member in the control and experimental groups.

Procedure

All subjects reported as a group to the lecture hall in which their class was normally held. Subjects were randomly assigned to one of three groups by means of a counting off procedure. Members of each group then re-convened in a room designated per the number assigned during the counting off procedure. Group 1 (45 S's) listened to an audio tape only presentation; Group 2 (40 S's) was presented with the audiotape / graphic lesson presentation and Group 3 (53 S's) was presented with the audio tape and the verbal list presentation.

All three groups were instructed to listen to the audiotaped presentation. During the taped lecture, groups 2 and 3 were shown the transparencies respectively at appropriate, simultaneous points during the audio taped presentation, while Group 1 was provided only with the audio taped presentation. At the conclusion of the taped presentation, all subjects were instructed to complete the recall exercise (Test #1). After a delay of 1 week, subjects reported to their standard lecture hall, and as a group, individually completed recall assessment Test #2.

Results

An analysis of variance was conducted for the three groups scores on Test #1 and a repeated measures analysis was conducted for Test #2. Results showed that for Test 1 there were significant differences, F (2, 135) = 4.34, p< .01, between the control and the experimental groups when assessing general recall efficacy. Significant differences were reported for the immediate recall efficacy of intentional items, F (2, 135) = 7.41. p< .01, between the control and experimental groups. A Neuman Keuls multiple comparison confirmed that experimental groups out-performed the control group (p< .05) for both general recall and intentional recall tasks but that neither the graphic nor the verbal displays were superior in their facilitation effect, either for general recall, for recall of critical items or for recall of incidental items. The repeated measures ANOVA for groups' scores on Test #2 showed no significant differences among means when assessing general delayed recall, the delayed intentional recall or the delayed incidental recall.

Method - Study 2

Materials

The same 7 minute, 21 second taped lecture describing a hypothetical communication holding company was used in the second study. Three separate cassette tapes provided for identical content and information presentation. The same two transparencies were employed in the second study as had been used in Study 1: one set displayed line drawings in which spatial relationships described in the tape were depicted, while the other set displayed lists of verbal descriptors to present the same concepts displayed in the graphic transparencies. The same two equivalent recall tests were used , as was the same demographic assessment instrument.

Subjects

44 (14 male, 30 female) volunteer subjects were recruited from an educational technology course for pre-service teachers. Subjects were provided with extra course credit for their participation in the experimental exercise if they completed both the initial recall assessment and the delayed recall assessment one week later.

Procedure

Students enrolled in the pre-service teacher educational technology course were invited to participate in an (simulated) enhanced audio teleconference; they were also told that the teleconference would include an assessment exercise in which all teleconference attendees were expected to participate. Students were asked to sign up for a specific time during which teleconferences were to be conducted. Members of each group were asked to re-convene in a "teleconference room" at the time selected by each participant on the sign-up sheet. Group 1 (14 S's) was provided with an audio tape only presentation; Group 2 (15 S's) was presented with the audiotape / graphic lesson presentation and Group 3 (15 S's) was presented with the audio tape and the verbal list presentation.

At the commencement of each session, all subjects were greeted by a site facilitator and were told that further instructions would be forthcoming via an expected teleconference call. The site facilitator answered the incoming phone call; subjects were greeted by a "teleconference presentor" who described the procedures to be followed during the experimental endeavor. (The "teleconference presentor" was actually the course instructor, making the call from an office telephone just down the hall form where the subjects were convened.) Each of the three groups were told to listen to the audiotaped presentation. As in Study 1, Groups 2 and 3 were shown the transparencies respectively developed per group at appropriate, simultaneous points during the audio taped presentation by the site facilitator, while Group 1 was provided only with the audio taped presentation. At the conclusion of the taped presentation, all subjects were instructed to complete the recall exercise (Test #1). After a delay of 1 week, subjects reported to the room in which the simulated teleconference had been held; as a group, individuals completed recall assessment Test #2.

Results

An analysis of variance was conducted for the three groups scores on Test #1 and a repeated measures analysis was conducted for Test #2. Results showed that for Test 1 there were significant differences $F(2, 42) = 3.27$, $p < .05$, between the control and the experimental groups when assessing general recall efficacy. Significant differences were reported for the recall efficacy of intentional recall items $F(2, 42) = 5.41$. $p < .01$, between the control and experimental groups. A Neuman Keuls multiple comparison confirmed that experimental groups out-performed the control group ($p < .05$) for both the general recall and the immediate recall tasks but that neither the graphic nor the verbal displays were superior in their facilitation effect, either for general recall or for recall of intentional items. There were no significant differences among experimental groups and the control group when assessing recall efficacy of the incidental recall items. The repeated measures ANOVA for groups' scores on Test #2 showed no significant differences among means when assessing general delayed recall, the delayed intentional recall or the delayed incidental recall.

Discussion

The results of the analysis of data derived from the first study indicated that conceptual information and information describing relationships among concepts which is presented in a large lecture instructional environment is better recalled when reiterative, secondary presentation forms accompany the initial presentation. These results were maintained in the second study.

even though the context of instructional delivery had been altered from that of a large lecture to that of an audio teleconference.. The use of adjunctive facilitators such as transparencies significantly improved student performance upon a written recall exercise administered immediately after the presentation of information in both cases. There was no significant difference between alphanumeric symbol facilitation and graphic symbol facilitation when considering overall recall performance, although there did appear as if the graphic transparencies demonstrated marginal superiority in improving recall performance.

Data derived from the second study indicated that conceptual information and information describing relationships among concepts which is presented in a (simulated) audiographic teleconference is better recalled when reiterative, secondary presentation forms accompany the initial presentation. The use of adjunctive facilitators such as transparencies significantly improved student performance upon a written recall exercise administered immediately after the presentation of information. There was no significant difference between alphanumeric symbol facilitation and graphic symbol facilitation when considering overall recall performance. As in the first study, the graphic mediators demonstrated marginal superiority to the verbal mediators.

In both studies the alphanumeric and graphic displays were employed as a means of providing an organizational structure within which novice learners would be better able to discern critical information from incidental information. As such, the displays were not use to maintain attention, nor were they used to decorate or add interest to the instructional materials (Beck, 1984). Using Levin's theoretical function of prose-relevant pictures as benchmarks, one can also discern that the display forms used in these three studies did not compensate for the relative inability of verbal presentation forms to transmit information, they did not motivate subjects to recall information more efficiently, they did not represent information, they did not aid in the interpretation of information, nor did they assist in the transformation of meaning. Of course, it is also important to keep in mind that while these benchmarks provided in Levin's (1981) prose-relevant picture framework can be used in this context, they were not generated for use with both alphanumeric and graphic presentation forms. The alphanumeric and graphic display forms were used to assist in the reiteration of verbally presented information by means of secondary presentation modes, while assisting in the generation of an externally imposed organizational framework through which recall could be facilitated. Even though the instructional process is generally desribed as an interactive one, many presentation modes encourage greater dependence upon one-way transmission of information. In large lectures and in many varieties of teleconferencing, the interaction between teacher and student is implied more than it is practiced; interaction may certainly be accomodated in these presentation modes, but is not necessarily encouraged. By embedding secondary presentation forms in a sequence of instruction, they may function as alternative representations (Van Patten, Chao & Reigeluth, 1986) through which learning, represented in this study by recall efficacy, may have been more efficient and effective.

These investigations were designed to simulate and/or replicate typical instructional situations in which opportunities for interaction and feedback were limited. For this reason, the assessment of performance outcomes elicited by means of the experimental materials occurred in two discrete instructional contexts. Even so, limitations which directly impacted attempts to simulate a true instructional situation need to be acknowledged. Actual time spent learning the taped lecture information was relatively short, and is not characteristic of typical instructional situations. Similarly, the only practice/rehearsal opportunity provided for subjects provided during the one-week delay period occurred with the administration of the first recall assessment exercise (Test #1). The lack of significance in the delayed recall assessments in both the alphanumeric or the graphic conditions was most likely due to the brevity of the treatment time. Anglin (1987) demonstrated that prose relevant picture retention has been maintained for several weeks; Mandler & Parker (1976) indicated that retention of spatial relationships from meaningful pictures can be retained for well over one week's time.

Conclusions

The ability of a novice learner to extract critical information provided by an expert may be hampered by the novices inability to discriminate between those bits of information which are critical for developing a conceptual framework and those bits of information which are not critical. In situations where interaction may be limited it may be even more difficult to learn how to discriminate between intentional and incidental information. Immediate recall of information identified as critical and reiterated by means of alphanumeric or graphic symbols was facilitated in a large lecture context and in a simulated enhanced audio-teleconference by means of employing secondary presentation forms to reiterate critical information and to provide an organizational framework to facilitate recall of intentional information.

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Title:

Predicting Behavior from Normative Influences: What Insights Can the Fishbein Model Offer?

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Predicting Behavior from Normative Influences:
What insights can the Fishbein Model offer?

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PREDICTING BEHAVIOR FROM NORMATIVE INFLUENCES:
What insights can the Fishbein Model offer?

The Fishbein Model is an attitude behavior consistency model based on a recursive causal chain structure which places normative influences in the middle of the chain: Acted upon by beliefs and in turn acting on behavioral intentions. The normative component is considered a major factor for influencing behavioral intentions along with an attitudinal component. This paper examines controversy surrounding the Fishbein Model's normative component. Results from a study of microcomputer use are presented and implications for educational research and practice are examined.

The Fishbein Model

The Fishbein Model is based on Fishbein and Ajzen's theory of reasoned action which presents progressive levels of specificity towards understanding the relationship between beliefs and behavior (See Fig. 1).

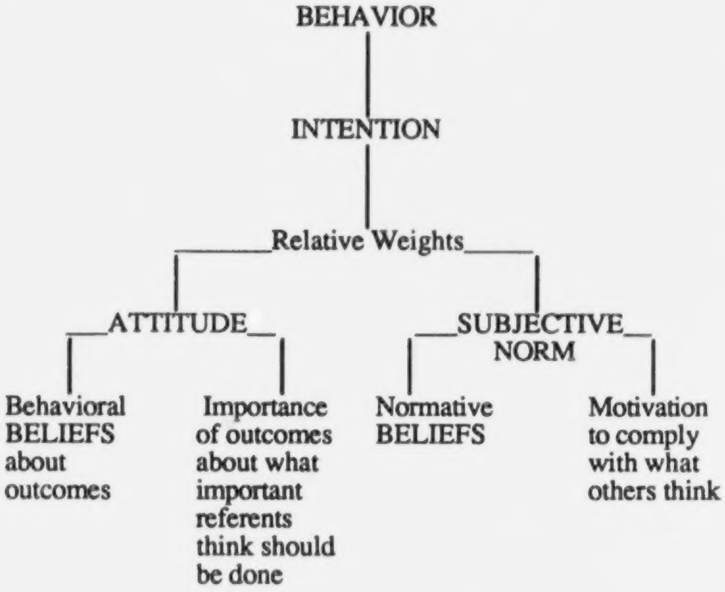
BEHAVIOR
INTENTION
Relative Weights
ATTITUDE
SUBJECTIVE NORM
Behavioral BELIEFS about outcomes
Importance of outcomes about what important referents think should be done
Normative BELIEFS
Motivation to comply with what others think

Fig. 1--Relationships beween components of the theory of reasoned action.

Attitudes and subjective norms are the predictors of behavioral intentions in the model. The weighting factors indicate their relative importance to the behavior under consideration. Cialdini, Petty and Cacioppo (1981) reported the normative concept caused more controversy than the attitude concept due to the varying nature of the component weights. Studies have found attitudes contributing more than subjective norms (Loken & Fishbein, 1980) and subjective norms contributing more than attitudes (Kantola, Syme & Campbell, 1982). In general, however, attitudes have been found to consistently contribute more to behavioral intentions (Cialdini et al, 1981).

Other objections to the normative component of the model are both methodological and rational (Miniard & Cohen, 1979, 1981). They focus on operational definitions of normative referents, unipolar vs bipolar measurement and specificity of behavioral domain. Fishbein and Azjen (1981) have countered criticisms rationally and empirically with refinements to normative measurement. In their view, unipolar measurement at the general level reflects the positive motivation to comply with people who are important to the individual. They do indicate scaling and specificity level may be related. Bipolar measurement may be useful if motivation to comply is specified at an intermediate rather than general level.

The Fishbein Model of behavioral intentions is used widely in both laboratory and field settings for predicting and understanding attitudinal and normative influences on behavior. One of the strengths of the model is its flexibility for behavior and population specific measurement. By using basic principles for creating questionnaires (Ajzen and Fishbein, 1980) results are directly based on beliefs of the target population. A sample of the population is interviewed to obtain the information which generates question construction. The study presented below used this method for examining library and information science (LIS) student's attitudes toward microcomputer use.

Normative Influences on LIS students' microcomputer use

Four criteria of specificity are involved in applying the Fishbein Model to understanding and predicting behavior: Target, action, context and time. The study this paper is based on (Walster, 1986) applied the complete Fishbein Model to two behaviors which differed only in their action elements: learning to use a microcomputer and using a microcomputer. Comparing student's responses under educational and non-educational conditions resulted in identification of areas where the action of learning influenced components of the model.

For purposes of this discussion only the normative implications of the study will be considered. Based on the problems with the normative component found in the literature, two issues are examined. The first is the type of referent: who were important normative influences and what were their characteristics?. The second is a measurement issue: What affect does unipolar or bipolar scaling have?

Normative Referents

The same eight normative referents were identified in interviews by the learning to use microcomputers and the using microcomputers groups as salient. Six were positive referents: Library users, professors, future employers, people who use computers, family and friends. Two were negative referents: People against technology and people threatened by computers. Comparing the groups' responses to these eight referents, significant differences were found for only one normative referent (See Table 1). Students in the learning group felt it was significantly more likely professors would be in favor of their learning to use a microcomputer.

Table 1. T values and means for normative beliefs (normative referents).

Referents	Group	n	M	SD	df	t
Professors	Learning	36	2.53	0.56		
	Using	32	1.97	0.97	66	2.96*
Future employers	Learning	36	2.39	0.77		
	Using	32	2.03	0.93	66	1.73
People using computers	Learning	36	2.25	0.99		
	Using	32	2.00	0.98	66	1.04
Friends	Learning	36	1.06	1.04		
	Using	32	0.84	0.99	66	0.86
Family	Learning	36	1.19	1.19		
	Using	32	1.00	0.98	66	0.73
Library users	Learning	36	0.89	1.19		
	Using	32	0.83	1.17	66	0.16
People against technology	Learning	36	-1.14	1.53		
	Using	32	-1.47	1.30	66	0.95
People who feel threatened by technology	Learning	35	-1.06	1.39		
	Using	32	-1.34	1.29	65	0.87

*p<.01

Both groups believed professors, people who use computers and future employers were most likely to be in favor of microcomputer use. Family and friends were judged by the groups to be only slightly likely to favor microcomputer use. People against technology and people who feel threatened by technology were thought to be unlikely to favor microcomputer use. These judgments are what the students believed the various referent groups would like them to do.

Miniard and Cohen (1981) stated that some referents will be positive and some referents will be negative. The Fishbein Model, however, assumes that only positive referents will be influential. This study resulted in positive and negative normative referents being salient to both groups. Negative referents need to be considered in predicting and understanding attitudes and behavior.

Responses to referents were different between the two groups. The learning group felt more strongly about the positive referents and less strongly about negative referents. The reverse was true for the using group. The learning action influenced responses to positive and negative referents.

Study of the affect of normative referents in the learning action could be useful for the design of instruction. In general, LIS education emphasizes service to the library user. This study clearly indicated library users were of minimal importance to student's microcomputer use. The future employer, however, was a strong normative concern to students. Instruction could be designed to increase student's motivation through greater consideration of employer concerns.

Motivation to Comply

Subjective norms consist of two parts: the normative belief (or normative referent) and the motivation to comply. The subjective norm is calculated by multiplying normative belief times motivation to comply. The controversy over unipolar or bipolar measurement relates specifically to motivation to comply. In this study both the learning group and the using groups' subjective norms were calculated with unipolar and bipolar scales.

Using bipolar measurement for subjective norms no significant differences were found (See Table 2). The sum of subjective norms also showed no significant differences between the groups (See Table 4). Six subjective norms resulted in positive normative beliefs and positive motivations to comply: library users, professors, future employers, people who use computers, family and friends. Two subjective norms resulted in negative normative beliefs and negative motivations to comply: people against technology and people who feel threatened by technology.

Table 2. T values and means for estimates of subjective norms using bipolar motivation to comply

Referents	Group	n	M	SD	df	t
Professors	Learning	36	3.61	3.43		
	Using	32	2.50	2.37	66	1.53
Future employees	Learning	36	4.44	3.44		
	Using	32	3.78	2.60	66	0.89
People who use computers	Learning	36	0.67	3.41		
	Using	32	-0.19	2.31	66	1.19
Friends	Learning	36	0.86	1.18		
	Using	32	0.31	1.55	66	1.33
Family	Learning	36	1.47	2.17		
	Using	32	1.93	2.01	66	0.87
Library users	Learning	36	0.72	2.46		
	Using	32	0.53	1.84	66	0.18
People against technology	Learning	36	2.25	4.08		
	Using	32	1.59	2.59	66	0.78
People who feel threatened by technology	Learning	35	2.42	3.53		
	Using	32	1.47	2.55	65	1.25

When unipolar measurement was used there were significant differences between the groups on three subjective norms (See Table 3): professors, people against technology and people who feel threatened by technology. The learning group was significantly more likely to believe that they would be influenced by what their professors wanted them to do. With people against technology and people who feel threatened by technology the using group was significantly more likely to be motivated not to comply.

Table 3. T values and means for estimates of subjective norms using unipolar motivation to comply

Referents	Group	n	M	SD	df	t
Professors	Learning	36	13.72	4.99		
	Using	32	10.38	5.66	66	2.59*
Future employers	Learning	36	14.00	5.91		
	Using	32	11.91	5.95	66	1.45
People who use computers	Learning	36	9.67	5.07		
	Using	32	7.81	4.34	66	1.61
Friends	Learning	36	5.08	4.35		
	Using	32	3.69	4.35	66	1.18
Family	Learning	36	6.25	6.44		
	Using	32	5.03	5.37	66	0.84
Library users	Learning	36	4.28	5.79		
	Using	32	4.00	5.35	66	0.20
People against technology	Learning	36	-2.36	3.79		
	Using	32	-4.28	4.31	66	2.01*
People who feel threatened by technology	Learning	35	-1.74	3.24		
	Using	32	-3.91	4.25	65	2.33* *p<.05

The sum of all normative beliefs times motivations to comply using unipolar scaling also showed significant differences between the two groups (See Table 4). The learning group was significantly more likely to comply with normative referents.

Table 4. T values and means for sums of all subjective norms.

Subjective Norm	Group	n	M	SD	df	t
Bipolar	Learning	36	16.44	15.35		
	Using	32	11.13	9.04	66	1.71
Unipolar	Learning	36	49.00	22.69		
	Using	32	34.63	23.18	66	2.58*

*p<.05

In this study more significant differences resulted when the measurement was unipolar. The implications of these results are unclear. Other researchers have found significant correlations with normative beliefs and motivations to comply measured bipolarly (Hom, 1979), with both measured unipolarly (Davidson & Jaccard, 1979) and with normative beliefs measured bipolarly and motivation to comply measure unipolarly (Fishbein & Ajzen, 1981). The controversy in this area is strong and unresolved. Fishbein and Ajzen's (1981) recommendations are to use unipolar measurement for motivations at the general level and bipolar measurement for motivations at the behavioral domain level.

Subjective norms are still problematic in using the Fishbein Model for predicting and understanding behavior. In this study students in the learning to use microcomputers group tended to be more strongly motivated to comply. One possible interpretation would be the action of learning created a need to comply. The controversy surrounding the motivation to comply construct, however, reduces the ability to make generalizations. It is an issue which requires further investigation. Researchers in education need to be aware of the problems. Clear definition of behavioral domains and measurement techniques is critical to understanding normative influences when using the Fishbein Model.

Recommendations for Applying the Fishbein Model

Applying the Fishbein Model in educational contexts has advantages and disadvantages. Characteristics of the normative referents and measurement issues affect both prediction and understanding. Normative referents positive or negative characteristics should be evaluated when constructing questionnaires and analyzing responses. Measurement scales for motivation to comply need to consider specificity of domain level and context. The Fishbein Model can be a useful tool for examining normative influences and behavior in education if it is applied and interpreted appropriately.

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Title:

An Examination of Two Approaches to Organizing Instruction

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An Examination of Two Approaches to Organizing Instruction

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Abstract

The purpose of this study was to examine the effects of instruction that is organized in two alternative formats -- hierarchical (Gagne, 1962) and elaborated (Reigeluth, 1979) -- on learners' recall and application of content-specific principles. Sixty-nine college juniors and seniors enrolled in an educational media production course studied one of two versions of instructional text dealing with photography-related principles. One version was organized using learning hierarchy prescriptions; the other using elaboration theory prescriptions. No statistically significant differences were found between the two treatment groups. However, the hierarchical version of the materials was considerably shorter and took less time to complete, thus raising questions about the efficiency and cost-effectiveness of instruction designed following elaboration theory prescriptions.

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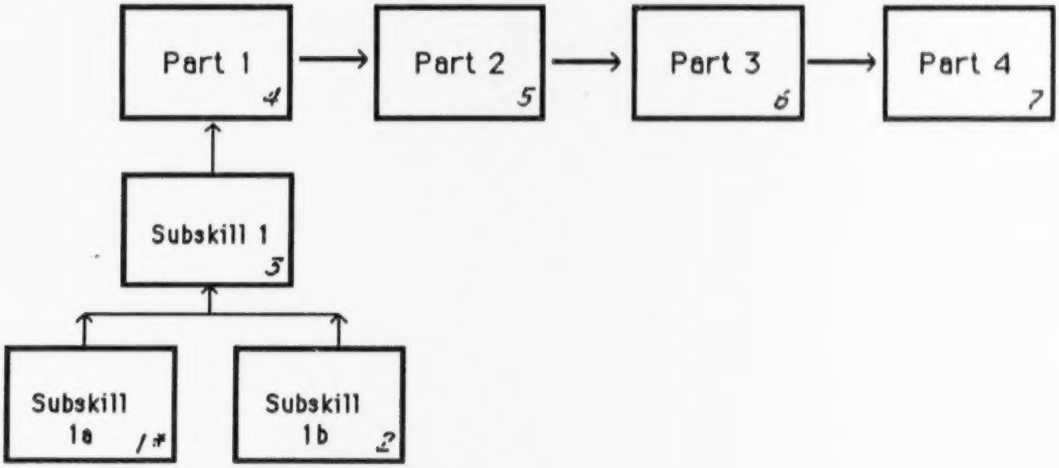
An Examination of Two Approaches to Organizing Instruction

Traditional models of instructional design most frequently have used learning hierarchies (Gagne, 1962) as the basis for organizing and sequencing instruction. Reigeluth (1979) criticized such an approach for creating instruction that is "highly fragmented," "demotivating," and "inconsistent with much knowledge about how learning occurs most effectively." (p. 8). Reigeluth argued that instruction will be more effective if organized using elaboration theory as a guide. The purpose of this study was to examine the effects of instruction that is organized in two alternative formats -- hierarchical and elaborated -- on learners' recall and application of content-specific principles. Secondarily, the study investigated whether these organizational formats are differentially effective for learners with particular cognitive styles.

Overview of Organizational Alternatives

When instruction is designed using learning hierarchy prescriptions, the designer first analyzes the instructional goal by breaking the goal down into its information processing components. Prerequisite skills and knowledge are then identified. When completed, such an analysis presents a hierarchy of skills and knowledge indicating what a learner must know before beginning instruction on the next skill or topic. Thus the organization and sequence of instruction is dictated by the prerequisite relationships of skills and knowledge identified in the hierarchy. As suggested in Figure 1, following this approach, instruction is usually sequenced in a parts-to-whole (bottom-to-top) and first-to-last (left-to-right) manner. Instruction organized according to learning hierarchy prescriptions is purported to be effective (because students learn everything they need to know in order to move on to the next higher skill) and efficient (because extraneous information is eliminated).

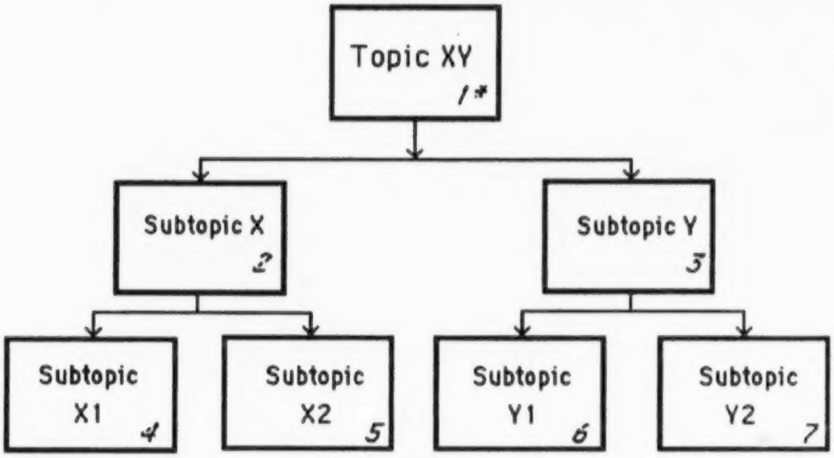
Figure 1. Graphic representation of learning hierarchy sequence.



Italic numbers indicate sequence of instruction.

When instruction is designed following elaboration theory prescriptions, the designer first selects the type of organizing structure -- conceptual, procedural, or theoretical -- that will be the basis for the instruction. Next, this organizing structure is developed; all important concepts, procedures, or principles are identified. The content is then allocated to "levels of elaboration" with the simplest, most fundamental content in an "epitome" (Reigeluth & Stein, 1983). An epitome is a introductory experience which presents the simplest content and provides the learner the opportunity to apply this content. More complex content is allocated to subsequent levels of elaboration. As indicated in Figure 2, the sequence of instruction is suggested by a general-to-specific, simple-to-complex (top-to-bottom) organization. Instruction organized according to elaboration theory prescriptions is purported to be effective and efficient (because new content is presented within the context of already-known content) and appealing (because the learner is aware of the overall context and the relationships among content elements).

Figure 2. Graphic representation of elaborated sequence.



* Italic numbers indicate sequence of instruction.

In addition to the simple-to-complex sequence and single type of organizing content, elaboration theory consists of five other instructional strategy components:

- summarizers
- synthesizers
- analogies
- learner control options (where appropriate)
- learning prerequisites (where needed).

An in-depth discussion of these strategy components can be found in Reigeluth and Stein (1983).

The research on elaboration theory is somewhat limited. This can, in part, be traced to the fact that elaboration theory is purported to be most effective for instruction involving several lessons dealing with several interrelated topics (Reigeluth, 1979) Thus, limited-scope research efforts (e.g., studies of single-concept learning or simple-procedure learning) are not appropriate when studying elaboration theory. The hypothesized advantages of elaboration theory will be realized only if the content is of sufficient amount and complexity that the interrelationships among content elements become important to the learning task.

Given the complexity of elaboration theory and learning hierarchical prescriptions, it is evident that no single study can adequately address all the relevant issues. A research agenda (Smith & Wedman, 1986) was developed to systematically examine the approaches and their effects on learning outcomes. The following questions were taken from that agenda and addressed in this research:
What is the relative effectiveness of hierarchically-based versus elaborated instruction in learning content-related principles? Are these two forms differentially effective across levels of field independence/dependence?
In particular the study sought to compare the effects of materials designed and organized with selected elaboration theory techniques to instruction solely organized using a learning hierarchy. It was hypothesized that instruction organized following selected elaborative techniques, prefaced with an epitome (thus creating a general-to-specific sequence) and rewritten to include end-of-lesson and end-of-set (i.e., end of instructional unit) synthesizers, would produce superior learning to instruction solely following learning hierarchy prescriptions.

The research also attempted to identify any interaction between instructional organization and the cognitive style variable -- field dependence/independence. Field independent learners tend to do well on cognitive tasks that require structuring and reorganizing content; field dependent learners have more difficulty with such tasks (Witkin, Moore, Goodenough & Cox, 1977). Given Reigeluth's charge that content organized following learning hierarchy prescriptions is "highly fragmented," it was hypothesized that the hierarchically organized instruction would be less effective for field dependent learners than the elaborated design because they would have more difficulty integrating the individual skills into integrated knowledge.

Methods

The subjects for this study were junior and senior students enrolled in two sections of an instructional media production course at a large midwestern university. Two sets of materials dealing with photography content were used in the study; both sets were designed to teach the terminal objective. The first set of materials was designed following learning hierarchy instructional prescriptions. The materials were then redesigned following selected elaboration theory prescriptions (an epitome and end-of-lesson and end-of-unit synthesizers) thus creating the second set of materials.

The learning hierarchy version consisted of 72 pages of instructional text organized into four lessons. The elaborated version consisted of 108 pages of instructional text organized into six lessons, the first being the epitome. The epitome required the subjects to make non-numerical predictions using principles related to photographic exposure and image clarity (e.g., If the shutter speed is increased, the aperture size must be made larger to get an equivalent exposure).

Four assessment instruments were used in the study. The Hidden Figures Test (French, Ekstrom, & Price, 1963) was used to measure the subjects along the field dependence/independence dimension. A 12-point pretest that assessed performance on direct application tasks was used to assess prior knowledge of the content. A 14-point posttest and delayed posttest was used to assess mastery of the content on the application level. The delayed posttest was patterned after the posttest but item specifics were changed to minimize item familiarity.

During the first week of the semester, the pretest and the Hidden Figures Test (HFT) were administered. Four weeks after the pretesting session, the subjects were randomly assigned (by coin flip) to study either the hierarchical or elaborated versions of the instructional materials. All studying was done during the regularly scheduled class time; a total of three hours was available for study. The subjects recorded the amount of time they studied the materials. The posttest was given whenever an individual indicated that he/she was ready. One week later, the subjects were given an unannounced delayed posttest.

Results

Pretest results indicated that, with few exceptions, the subjects were complete novices in terms of the photographic content used in the study. Table 1 shows the descriptive statistics for the pretest, posttest, delayed posttest, and Hidden Figures Test results for each treatment group.

Table 1. Mean Test Scores for Treatment Groups by Version

Test	Version	Mean	S.D.	Range	N
Pre	Elaborated	0.58	0.96	0-3	31
	Hierarchical	0.52	0.98	0-4	38
Post	Elaborated	6.32	2.78	1-11	31
	Hierarchical	6.89	3.10	2-13	38
Delayed	Elaborated	5.80	2.87	0-12	31
	Hierarchical	6.89	2.84	1-12	38
HFT	Elaborated	10.87	7.07	2-26	31
	Hierarchical	8.34	3.99	2-17	38

The average study time for the elaborated materials was 114 minutes compared to 88 minutes for the hierarchical materials. This was inconsistent with pilot test results which had indicated approximately equal times for each each version of the materials.

Using the General Linear Model in SAS (1985), a two-way ANOVA was conducted to test the following hypotheses:
1) there would be no statistically significant difference between the two treatment groups' scores on either the posttest or the delayed posttest.
2) there would be no statistically significant difference between field dependent and field independent learners' scores on either the posttest or the delayed posttest.
3) there would be no statistically significant interaction between treatment and field dependence/independence.
Tables 2 and 3 present a summary of these analysis.

Table 2. Analysis of Variance: Posttest

Source	SS	df	F	PR>F
Treatment	5.314	1	0.60	.441
FI/FD	13.608	1	1.54	.219
Interaction	0.098	1	0.01	.916

Table 3. Analysis of Variance: Delayed Posttest

Source	SS	df	F	PR>F
Treatment	19.734	1	2.40	.126
FI/FD	11.696	1	1.42	.237
Interaction	0.098	1	0.16	.694

In the first statistical hypothesis, the posttest and delayed posttest scores of the hierarchical group were compared to the posttest and delayed posttest scores of the elaboration group. For the posttest scores, an F value of 0.60 resulted from the analysis, with a probability ratio of .441. For the delayed posttest scores, an F value of 2.40 resulted from the analysis, with a probability ratio of .126. Thus, no statistically significant difference was found between the two treatment groups' scores on either the posttest and or the delayed posttest.

To test the second hypothesis, posttest and delayed posttest scores of the field dependent group were compared to the posttest and delayed posttest scores of the field independent group. For the posttest scores, an F value of 1.54 with a probability ratio of .219 was obtained. For the delayed posttest scores, an F value of1.42 with a probability ratio of .237 was obtained. Thus, no statistically significant difference was found between the field dependent and field independent groups' scores on the posttest and delayed posttest.

The third analysis was conducted to check for an interaction between treatment and field dependence/independence for posttest and delayed posttest scores. For the posttest scores, an F value of .01 was calculated with a probability ratio of .91675. For the delayed posttest scores, an F value of .16 was calculated with a probability ratio of .694. Thus, no statistically significant interaction between treatment and field dependence/independence was found. (Note: Similar tests were run using extreme scores (top quartile/bottom quartile) on the Hidden Figures Tests. No significant interactions were found.)

Discussion

The results of this study did not support the prediction that students receiving instruction following elaboration techniques would outperform students receiving instruction following strict learning hierarchy prescriptions. Statistical analysis of test scores indicated no significant difference between the elaborated and hierarchical treatment groups. Such a finding is contrary to Reigeluth's prediction that elaborated instruction will produce more stable cognitive structures, thus improving long term retention. The research findings are discussed below, first in terms of future research and then in terms of implications for instructional design practice.

Elaboration theory was developed as a macro-level approach to organizing instruction, that is, sequencing instruction dealing with several interrelated topics. This instruction was a multi-topic, 1 and 1/2 to 2 hour unit involving application of several complex, interrelated principles. It was expected that the benefits of the integrating potential of elaborated instruction would be detectable in such a situation, especially with learners of such low levels of prior knowledge. It is possible that the content used in the study was still not of sufficient amount and/or complexity for the purported advantages to be realized. Further investigation with larger amounts of complex content may provide support for elaboration theory prescriptions and help answer the question of when to use the prescriptions.

The subjects' perceptions of the learning task and materials may have influenced their performance on the posttests. Subjects working with the elaborated materials first studied the epitome, which presented the content in a general manner without mention of numerical relationships, and then studied a more detailed treatment of the content. Subjects working with the hierarchical materials were presented with only the detailed content. It is possible that the elaborated treatment group retained the general relationships and tended to dismiss the numerical specifics. Future research might assess learners' ability to apply the principles in both general and numerical applications to determine if the two sets of materials are differentially effect at these two levels.

Students' performance was surprisingly low for both groups with means of 6.32 and 6.89 (on a 14 point scale) for the elaborated and hierarchical, respectively, on the immediate posttest and 5.80 and 6.89 (on a 14 point scale), respectively, on the delayed posttest. The materials were developed to have a high conceptual density in order to heighten the need for integration of information. However, the conceptual load may have been so high that students became overwhelmed and undermotivated. Further research with these same materials may utilize several sessions in order to avoid this potential problem.

The failure to identify an interaction between the treatment variable and field dependence/independence does not rule out the possibility that learner variables might have confounded the research findings. Cell sizes were rather small to detect such interactions. Future research involving larger samples or other measures and dimensions of cognitive style might reveal stable relationships which could be incorporated into elaboration theory or learning hierarchy prescriptions.

In spite of the failure to find a significant difference that could be attributed to instructional treatment, this study has implications for instructional design practice, at least when dealing with a few interrelated principles. The presence of the epitome lesson and the end-of-lesson and end-of-set synthesizers made the elaborated materials approximately 50% longer than the hierarchical materials (108 pages versus 72 pages). Thus, if materials' cost is an issue, designers might opt for a hierarchical organization because of reduced production/duplication costs. The extra length of the materials was directly related to the amount of time the subjects took to complete the material, an average of 114 minutes for the elaborated version versus 88 minutes for the hierarchical. (And, interestingly, the increased time on task did not bolster the performance of the students interacting with the elaborated version.) Thus, if learning efficiency is an issue, designers might again opt for a hierarchical organization.

Conclusion

The results of this study offers no support for the use of elaboration theory prescriptions when designing instruction dealing with a few interrelated principles. Three conclusions stand out. The general-to-detailed sequence and periodic synthesizers resulted in materials that were: 1) more expensive, 2) less efficient, and 3) no more effective than materials designed following learning hierarchical prescriptions. Perhaps future research dealing with larger amounts of content will provide evidence to the contrary.

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Title:

Factors Related to the Skipping of Subordinate Skills in Gagne's Learning Hierarchies

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Factors Related To The Skipping of Subordinate Skills in Gagne's Learning Hierarchies

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Statement of the Problem

In 1962, Gagne introduced the learning hierarchy model as a theory of knowledge acquisition. He suggested that a skill could not be acquired unless the learners possessed certain prerequisite skills, which were identified by asking the question "What would the individual have to be able to do in order that he can attain successful performance on this task, provided that he is given only instructions?" (p.358). The same question was then applied to each prerequisite skill. As a result, a hierarchy could be derived.

In the same article, Gagne proposed that the learning hierarchy theory had two hypotheses: "a) no individual could perform the final task without having these subordinate capabilities...; and b) that any superordinate task in the hierarchy could be performed by an individual provided suitable instructions were given, and provided the relevant subordinate knowledge could be recalled by him" (p. 356).

Although Gagne (personal communication, January, 1988) argued that the fourth edition of his book The Conditions of Learning (1985) provided a more updated and refined account of the hierarchy theory, a close examination indicated that the fundamental points remained the same (Yao, 1989).

In 1968 Gagne published another important article about the learning hierarchy. In this article, he pointed out that a learning hierarchy could not represent a unique or most efficient route for any given learner. Instead, what it represents is the most probable expectations of greatest positive transfer for an entire sample of learners. An individual learner does not necessarily have to acquire each subordinate skill precisely in hierarchical sequence in order for him to learn the final task.

He further explained that nothing in the analysis method which derives the hierarchies told us about the capabilities of the individual learners. Therefore, he stated that "a given individual may be able to 'skip' one or more of the subordinate tasks, just as a given learner may be able to 'skip' parts of an adaptive program of instruction [p.3 (Gagne, 1968)]."

However, this important point has been ignored by most people since it was first addressed by Gagne. Many learning hierarchies researchers have focused their investigations on testing the validity of hierarchies. A review of the literature on learning hierarchies has revealed that the skipping of subordinate skills has never been studied (Yao, 1989).

Focus of the Study

The purpose of this study was to investigate the following two issues:

1. Can some learners skip?
2. What are the factors that influence a given individual's potential for skipping?

Skipping in this study is defined as 1) from instructional perspective, a situation where instruction on one or more skills in a learning hierarchy is omitted, and 2) from the learner's perspective, the capability to obtain on one's own the skills that are omitted from instruction and the superordinate skill to those skills.

The hypotheses and questions this study attempted to examine included:

1. Some learners can skip one or more subordinate skills of a given hierarchy and still achieve the terminal objectives.

2. The extent to which a learner can skip depends on 1) the individual's content-related ability and 2) the skipping size, defined as the number of skills skipped.

    2.1 Learners perform less well when the skipping size is large or when more skills are skipped.

    2.2 Higher-ability learners perform better than lower-ability learners on the skipped skill(s) and on the superordinate one(s).

The Hierarchy

This study requires the use of a learning hierarchy that has already been validated. A hierarchy of kinematics (see Figure 1 and Table 1) was chosen because it has been validated by White (1974), White and Gagne (1978), and Dick (1980), and has been used in 2 other studies (Kee & White, 1979; Trembath & White, 1978-79).

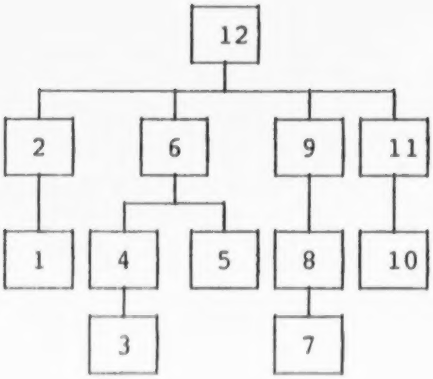
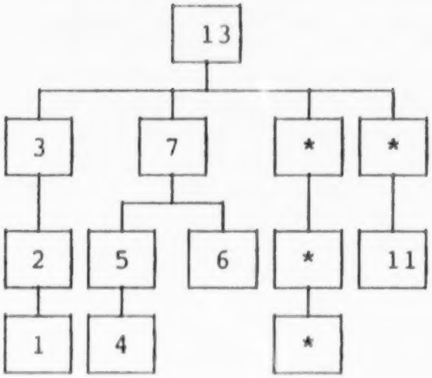


Figure 1
The Original Hierarchy



(* eliminated)

Figure 2
The Revised Hierarchy

However, a few modifications were made in the hierarchy actually used in the experiment (see Figure 2 and Table 1):

1. Skill #2 in the original hierarchy was broken down into 2 skills (#2 and #3) in the revised hierarchy.

2. Skill #7, #8, and #9 in the original hierarchy were eliminated from the actual hierarchy because they have been invalidated in all of the 3 validation studies mentioned above. The explanations offered by the researchers was that these elements are in the domain of verbal knowledge, not of intellectual skills, to which learning hierarchies apply.

   These three elements define the slope of a line on a position-time graph as the speed of the movement represented by that line. By eliminating these elements, students would be given the formulae to calculate the speed directly without involving the slope at all.

3. Skill #11 in the original hierarchy was eliminated in the revised hierarchy in order to simplify the treatment and to have better control of the experiment. Skill #11 deals with the unit of speed. To take care of this gap, the units were provided throughout the instructional booklet and the posttest.

Table 1: Elements of the Hierarchies

The Original Hierarchy	The Revised Hierarchy
1. Finds time after start on a position-time graph.	1. Finds time after start on a time line.
	2. Finds time after start on a position-time graph.
2. Calculates time interval between two points on a position-time graph.	3. Calculates time interval between two points on a position-time graph.
3. Finds displacement from start on position axis of a position-time graph.	4. Finds displacement from start on a position line.
4. Finds displacement from start on a position-time graph.	5. Finds displacement from start on a position-time graph.
5. Calculates displacement between two points on a position line.	6. Calculates displacement between two points on a position line.
6. Calculates displacement between two points on a position-time graph.	7. Calculates displacement between two points on a position-time graph.
7. States that line with biggest slope in position-time graph represents biggest velocity.	8. (eliminated)
8. Grades lines on position-time graph in order of velocities.	9. (eliminated)
9. States slope of position-time graph is velocity.	10. (eliminated)
10. Calculates slope of line given vertical and horizontal intercepts.	11. Calculates slope of line given displacement and time interval.
11. Calculates slope of line with units.	12. (eliminated)
12. Calculates velocity represented by straight line on position-time graph.	13. Calculates speed represented by straight line on a position-time graph.

Pilot Study

After the hierarchy was chosen, a pilot study was conducted in order to:

- improve the experimental instruments.
- select the appropriate grade level(s) for this particular hierarchy.
- find out the amount of time needed for the treatment.

Forty-five students from grades 5, 6, 7, and 8 participated in the pilot study, in which the 7th and 8th graders took only the pretest, and the 5th and 6th graders took the pretest and read the instructional booklet. The results of the pilot study showed that:

- most of the 7th and 8th graders and a few 5th and 6th graders had mastered all the skills in the hierarchy.

- most of the 5th and 6th graders had mastered the basic skills (i.e., subtraction and division) necessary for the learning of the skills in the hierarchy.

Based on the results of the pilot study, the 5th and 6th grades were chosen as the appropriate grade level for the experiment.

Experimental Materials

The instruments in this study included:

1. A pretest, which tested the subjects on subtraction (5 items), division (5 items), skill #1 (2 items), skill #2 (6 items), skill #3 (3 items), skill #4 (2 items), skill #5 (6 items), skill #6 (2 items), and skill #7 (3 items).

2. An instructional booklet, which taught subjects all the skills but the one(s) they were supposed to skip according to the treatment they were assigned into. For each skill that was taught, instructions were presented followed by practice items and, then, feedback (i.e., the correct answer and solution to the problem). For the skill that was to be skipped, two questions were presented, but no feedback was given. Subjects were only asked to solve the problem on their own.

3. A posttest, which tested subjects on skills #2, #3, #5, #7, #11, and #13 (5 items for each skill).

Procedure

One hundred and seventy-three (173) 5th and 6th grade students participated in the experiment. Among them, 93 were in 6th grade and 80 were in 5th grade. Mathematics scores from the California Achievement Test (CAT) were obtained for each participant, which included computation, concept & application, and total grade equivalent scores.

All 173 subjects took the pretest one week prior to the treatment. Based on the pretest results, a profile of the entry level performance was obtained for each subject. This profile contained the pass/fail pattern for each skill tested in the pretest. Table 2 lists the patterns for skills #2, #3, #5, and #7, which were particularly critical to the experiment.

Out of these 173 participants, 32 (24 in 6th grade and 8 in 5th grade) had possessed all the skills in the hierarchy. Their data were excluded from final analysis. This left 141 subjects whose data were to be used.

Based on the math total grade equivalent scores from CAT, these 141 subjects (5th and 6th graders combined) were divided into 2 groups: higher and lower ability. The scores ranged from 2.8 to 12.0 and the median score for the entire group (5.9) was used as the cutting point to divide the groups. The resulting means of the math total scores for the higher-ability group was 7.44 (n = 69) and for the lower-ability group was 4.92 (n = 72).

Based on subjects' entry level profile, each of the 141 individuals was further assigned into one of four treatment groups. The rule for the assignment was: a subject could not be assigned into a treatment which was going to skip the skill(s) he/she already possessed.

The treatment lasted for 2 days, 1 class session on each day. On Day 1, subjects read Part 1 of the instructional booklet. On Day 2, they finished Part 2 of the booklet and then took a posttest.

Research Design

A 4 x 2 factorial design was used. Four levels of skipping treatment were crossed with two levels of mathematics ability (higher and lower). The four treatments included:

- Treatment 1 -- skipped skills #3 and #7
- Treatment 2 -- skipped skill #3
- Treatment 3 -- skipped skills #2 and #3
- Treatment 4 -- skipped none (control group)

Seven dependent measures were used. These measures came from individual scores for the six skills tested in the posttest (#2, #3, #5, #7, #11, and #13) and a total score by adding these six scores together.

Table 2:
Pass/Fail Patterns for Skills #2, #3, #5, & #7 in Pretest

Pattern	Skill #2	#3	#5	#7	# of Ss	Available Treatments
a.	+	+	+	+	32	none
b.	-	+	+	+	1	T4
c.	+	-	+	+	5	T2,T4
d.	+	+	-	+	2	T4
e.	+	+	+	-	7	T4
f.	-	+	-	+	1	T4
g.	+	-	+	-	15	T1,T2,T4
h.	-	+	+	-	1	T4
i.	-	-	+	+	29	T2,T3,T4
j.	+	+	-	-	10	T4
k.	+	-	-	-	7	T1,T2,T4
l.	-	-	+	-	13	T1,T2,T3,T4
m.	-	+	-	-	7	T4
n.	-	-	-	+	2	T2,T3,T4
o.	-	-	-	-	41	T1,T2,T3,T4
					Total: 173	

(+ : Pass; - : Fail)

T1: skipped skills #3 and #7
T2: skipped skill #3
T3: skipped skills #2 and #3
T4: skipped none

Research Results

ANOVA's were conducted on all of the 7 dependent measures. A summary of the results is presented in the table below. Whenever significant differences occurred, Scheffe's post hoc analysis was used for pairwise and complex comparisons.

Table 3: Summary of ANOVA Results

Variables	Treatment	Ability	2-way Interaction
Skill-2	F(3,133)=2.425 p = 0.069	F(1,133)=22.784 p = 0.000**	F(3,133)=1.603 p = 0.192
Skill-3	F(3,133)=4.161 p = 0.007*	F(1,133)=31.184 p = 0.000**	F(3,133)=2.595 p = 0.055
Skill-5	F(3,133)=0.849 p = 0.469	F(1,133)=9.460 p = 0.003**	F(3,133)=1.348 p = 0.262
Skill-7	F(3,133)=1.745 p = 0.161	F(1,133)=14.160 p = 0.000**	F(3,133)=1.195 p = 0.314
Skill-11	F(3,133)=1.735 p = 0.163	F(1,133)=18.314 p = 0.000**	F(3,133)=0.359 p = 0.783
Skill-13	F(3,133)=1.361 p = 0.257	F(1,133)=19.427 p = 0.000**	F(3,133)=0.292 p = 0.831
Total	F(3,133)=1.638 p = 0.184	F(1,133)=33.841 p = 0.000**	F(3,133)=1.148 p = 0.332

* significant at 0.01 level
** significant at 0.005 level

The results of the ANOVA's indicated that the ability effect was highly significant ($p < 0.005$) on all dependent measures. However, analyses showed no significant treatment effect on any dependent measures except skill #3 ($p = 0.007$). A treatment-by-ability interaction was also found on skill #3 ($p = 0.055$).

Multiple comparisons using the Scheffe method were conducted on skill #3 to identify which means were significantly different. Results indicated that treatment groups 3 and 4 were significantly different from each other ($p = 0.014$), and the control group (treatment 4) was different from the other three skipping groups combined ($p = 0.015$).

Discussion

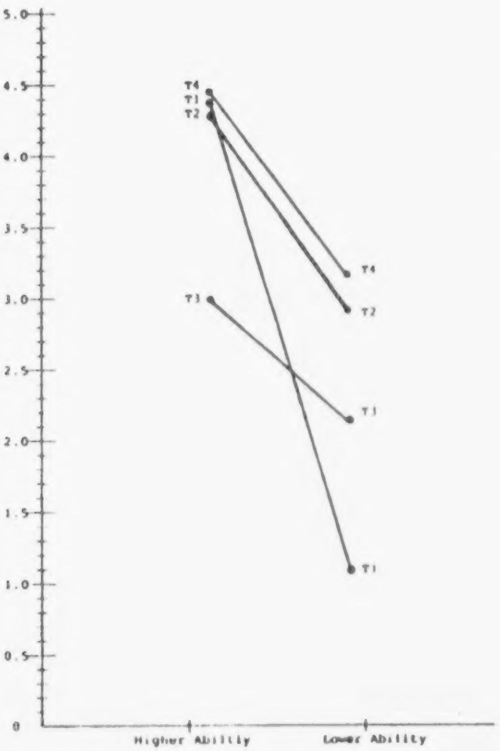
The results generally agreed with the hypothesis that some learners can skip, and highly supported that a learner's ability can influence his or her performance in a skipping situation. In this study, higher-ability learners outperformed lower-ability learners on the skipped skills (#2, #3, and #7) and on the superordinate one (#13). Furthermore, no skipping effect was found on skills #2 and #7, which were skipped in treatment 3 and treatment 1 respectively, and on the superordinate skill #13. In other words, regardless of whether skill #2 and skill #7 were skipped, no effect was found on subjects' performance on these two skills and the superordinate skill #13 when compared to the non-skipping group. This suggested that higher-ability subjects who did not learn one of these skills were able to "fill in the gap".

Significant treatment effect, however, was found on skill #3. This effect was contributed by the mean differences between treatment groups 3 and 4, and between the three skipping groups combined and the control group. That is, when skills #2 and #3 were skipped (treatment 3), subjects performed significantly less well than the non-skipping group on skill #3. Since skill #2 is subordinate to skill #3, this finding suggested that when both the subordinate (#2) and its superordinate (#3) skills were skipped at the same time, subjects were less able to fill in the gap. This applied to both higher-ability and lower-ability learners.

Furthermore, it should be noted that although the composite mean of the three skipping groups differed significantly from the non-skipping group, no significant differences were found when treatment groups 1 and 2 were individually compared to the control group. This may be due to the fact that all three skipping conditions involved skill #3: treatment 1 skipped skill #3 and a coordinate skill #7 (horizontal skipping); treatment 2 skipped skill #3; treatment 3 skipped skill #3 and a subordinate skill #2 (vertical skipping). This finding suggested that skipping skill #3 and another skill directly related to it significantly decreased subjects' performance on this skill when compared to the non-skipping group.

It should also be noted that larger skipping size did not necessarily affect subjects' performance in an equal manner. For example, both treatment 1 and treatment 3 skipped two skills, but only subjects in treatment 3 performed significantly less well than the non-skipping group on skill #3. This findings suggested that in addition to the skipping size, the type of skipping (e.g., horizontal or vertical) may also affect a learner's performance in a skipping condition.

Figure 3: Treatment-by-ability Interaction for Skill #3 Scores



Since a treatment-by-ability interaction existed on skill #3, group means were plotted in Figure 3. This figure interestingly revealed that lower-ability subjects were adversely affected more by the skipping condition in treatment 1 than in others. There was a drastic drop of performance by lower-ability learners when both skills #3 and #7 were skipped. This implied that skill #7, a coordinate to skill #3, might be more critical for lower-ability learners to obtain skill #3 than the subordinate skill #2. This result, though ungeneralizable to other instances where different hierarchies are used, suggested that different skipping conditions variously affected learners with different abilities.

In summary, the results of this study supported the hypothesis that skipping one or more subordinate skills does not affect some learners' performance on the skipped skills and the skill above them. Subjects' performance in a skipping condition depends on the content-related ability of the individual, the skipping size, and the type of skipping (coordinate or subordinate).

Implications for Instructional Design and Future Research

This study offered some rough guidelines in prescribing instruction or learning assignments to learners. Firstly, teachers and instructional designers may save higher-ability learners some time by omitting instruction on certain skills. In so doing, learning efficiency for those learners can be increased without degrading their learning performance.

Secondly, to facilitate a learner's performance in a skipping condition, selection of the skill(s) to be skipped can be crucial. If more than one skill is to be skipped, horizontal skipping (i.e., the skipping of a skill and its coordinate) may result in better performance than vertical skipping (i.e., the skipping of a skill and its immediate subordinate). This guideline, however, applies only to higher-ability learners. Results of the study suggested that lower-ability learners may have more trouble in a horizontal skipping condition.

These two guidelines should be used with caution. This is because the generalizability of findings from this study may be determined by the type of learning hierarchies used (e.g., subject area, specific content, scope, etc.), the position of the skipped skill(s) in the hierarchy, target population, and subjects' prior knowledge directly and indirectly related to the hierarchy. More research, therefore, needs to be done with different learning hierarchies and populations before any generalizations can be made with confidence. In addition to generalizability, other issues of skipping also need further exploration, some of which are mentioned here: the position of skipped skill(s), the type of skipping (vertical or horizontal), and more specific learner attributes of those who can skip and who cannot.

This study provided a new insight to Gagne's learning hierarchies theory. Its implications may impact on the practice of classroom teachers and instructional designers regarding the instructional prescriptions given to a learner. Although not without its flaws, this study will serve its purpose if more research along this line will follow.

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